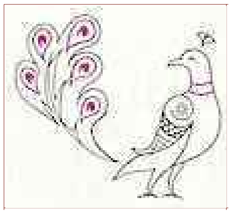
"India is the world's most ancient civilization. Nowhere on earth can you find such a rich and multi-layered tradition that has remained unbroken and largely unchanged for at least five thousand years. Bowing low before the onslaught of armies, and elements, India has survived every invasion, every natural disaster, every mortal disease and epidemic, the double helix of her genetic code transmitting its unmistakable imprint down five millennia to no less than a billion modern bearers. Indians have demonstrated greater cultural stamina than any other people on earth. The essential basis of Indian culture is Religion in the widest and most general sense of the world. An intuitive conviction that the Divine is immanent in everything permeated every phase of life," says Stanley Wolpert.

Indic civilization has enriched every art and science known to man. Thanks to India, we reckon from zero to ten with misnamed "Arabic" numerals (Hindsaa - in Arabic means from India), and use a decimal system without which our modern computer age would hardly have been possible.

Science and philosophy were both highly developed disciplines in ancient India. However, because Indian philosophic thought was considerably more mature and found particular favor amongst intellectuals, the traditions persists that any early scientific contribution came solely from the West, Greece in particular. Because of this erroneous belief, which is perpetuated by a wide variety of scholars, it is necessary to briefly examine the history of Indian scientific thought. From the very earliest times, India had made its contribution to the texture of Western thought and living. Michael Edwardes, author of British India, writes that throughout the literatures of Europe, tales of Indian origin can be discovered. European mathematics - and, through them, the full range of European technical achievement – could hardly have existed without Indian numerals. But until the beginning of European colonization in Asia, India's contribution was usually filtered through other cultures.

"Many of the advances in the sciences that we consider today to have been made in Europe were in fact made in India centuries ago." - Grant Duff British Historian of India. Dr. Vincent Smith has remarked, "India suffers today, in the estimation of the world, more through the world's ignorance of the achievements of the heroes of Indian history than through the absence or insignificance of such achievement."

Introduction
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Science
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Chemistry and metallurgy
Shipbuilding and Navigation
Commerce
Wealth



Introduction

According to American Historian **Will Durant** **The Story of Civilizations - Our Oriental Heritage** ISBN: 1567310125 1937 p.391-396:

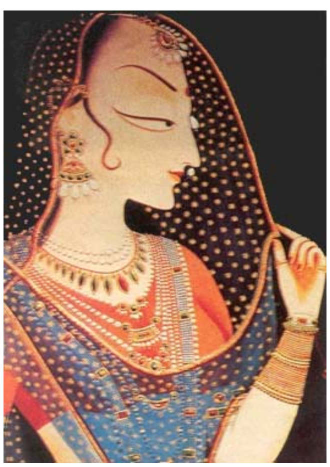


"From the time of Megasthenes, who described India to Greece ca 302 B.C., down to the eighteenth century, India was all a marvel and a mystery to Europe. Marco Polo (1254-1323) pictured its western fringe vaguely, Columbus blundered upon America in trying to reach it, Vasco da Gama sailed around Africa to rediscover it, and merchants spoke rapaciously of "the wealth of the Indies."

" It is true that even across the Himalayan barrier India has sent to us such questionable gifts as grammar and logic, philosophy and fables, hypnotism and chess, and above all our numerals and our decimal system. But these are not the essence of her spirit; they are trifles compared to what we may learn from her in the future. As invention, industry, and trade bind the continents more closely, and shall absorb, even in enmity, some of its ways and thoughts."

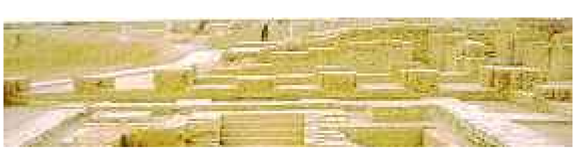
"The indications are that Mohenjadaro was at its height when Cheops built the first great pyramid; that it had commercial, religious and artistic connections to Sumeria and Babylonia...as **Sir John Marshall** believes, **Mohenjadaro represents the oldest of all civilizations known."**

The medieval Arab scholar **Sa'id Ibn Ahmad al-Andalusi** (1029-1070) wrote in his **Tabaqat al-'umam,** one of the earliest books on history of sciences:



"The first nation to have cultivated science is India. ... India is known for the wisdom of its people. Over many centuries, all the kings of the past have recognized the ability of the Indians in all the branches of knowledge... The kings of China have stated that the kings of the world are five in number and all the people of the world are their subjects. They mentioned the king of China, the king of India, the king of the Turks, the king of the Persians, and the king of the Romans... **They referred to the king of India as the "king of wisdom"** because of the Indians' careful treatment of ulum (sciences) and all the branches of knowledge. ... The Indians, known to all nations for many centuries, are the metal (essence) of wisdom, the source of fairness and objectivity. They are people of sublime pensiveness, universal apologues, and useful and rare inventions. ... To their credit the Indians have made great strides in the study of numbers and of geometry. They have acquired immense information and reached the zenith in their knowledge of the movements of the stars (astronomy).... After all that they have surpassed all other peoples in their knowledge of medical sciences.."

Sir William Wilson Hunter author of the book, **The Indian Empire,** said India," has even contributed to modern medical science by the discovery of various chemicals and by teaching you how to reform misshapen ears and noses. Even more it has done in mathematics, for algebra, geometry, astronomy, and the triumph of modern science -- mixed mathematics -- were all invented in India, just so much as the ten numerals, the very cornerstone of all present civilization, were discovered in India, and are in reality, Sanskrit words."



Beginning with the earliest known Indian civilization, the Indus Valley, with its pottery wheel, cotton textiles, Indus script, and two wheeled carts, there is a good deal of material and texts to work from. By the



beginning of the third millennium B.C. in India, as in China, Egypt, and Mesopotamia, scientific development was well advanced. **Excavations carried on at the sites of the Indus civilization have revealed remnants of an ancient civilization unsurpassed in civil engineering accomplishments, particularly baths and drainage.** Whilst much is known of the hygienic measures of the period, little is known of the scientific knowledge upon which it was based. From the town Planning and Great Baths of Indus Valley it is evidence in the neat arrangement of the major buildings contained in the citadel, including the placement of a large granary and water tank or bath at right angles to one another. The lower city, which was tightly packed with residential units, was also constructed on a grid pattern consisting of a number of blocks separated by major cross streets. Baked-brick houses faced the street, and domestic life was centered around an enclosed courtyard. The cities had an elaborate public drainage system, Sanitation was provided through an extensive system of covered drains running the length of the main streets and connected by chutes with most residences. In the valley of the Indus River of India, the world's oldest civilization had developed its own system of mathematics.

This civilization is known for its well planned cities, brick built houses, excellent drainage system and water storage tanks. **Benjamin Rowland** (1904-1972) author of **Art and Architecture of India** wrote: "Indeed it could be said that the population of the Indus cities lived more comfortably than did their contemporaries in the crowded and ill-built metropolises elsewhere. People were literate and had their own script. Dance and music formed essential part of their daily life."



They had wide main streets and were magnificently laid out in grid form, reflecting careful town planning. They had sewers, municipal water systems, public baths, and well-fortified citadels. The private houses were well built, of fine solid baked bricks which have not crumbled over the centuries. Many of them were two stories high, and had seat latrines and chutes for refuse. Homes were built around courtyards. The people of the Indus Valley civilization had an advanced technology. They knew how to make cotton cloth and copper and bronze castings and forgings. **Some of their art objects have a wonderful simple realism. The torso of one small dancing figure is so unbelievably alive that one can almost feel the easy muscles at work under the smooth skin.**

(source: **India: A World in Transition - By Beatrice Pitney Lamb** p. 20).

"Mohenjo-daro had some of the most advanced toilets and sewers, with lavatories built into the outer walls of houses. There were “Western-style” toilets made from bricks with wooden seats on top. They had vertical chutes, through which waste fell into street drains or cesspits. Sir Mortimer Wheeler, the director-general of archaeology in India from 1944 to 1948, wrote: **“The high quality of the sanitary arrangements could well be envied in many parts of the world today.”**

Nearly all of the hundreds of houses excavated had their own bathing rooms. Generally located on the ground floor, the bath was made of brick, sometimes with a surrounding curb to sit on. The water drained away through a hole in the floor, down chutes or pottery pipes in the walls, into the municipal drainage system. **Even the fastidious Egyptians rarely had special bathrooms."**

The Indian architects designed sewage disposal systems on a large scale, building networks of brick effluent drains following the lines of the streets. The drains were seven to ten feet wide, cut at two feet below ground level with U shaped bottoms lined with loose brick easily taken up for cleaning. At the intersection of two drains, the sewage planners installed cesspools with steps leading down into them, for periodic cleaning. By 2700 B.C. these cities had standardized earthenware plumbing pipes with broad flanges for easy joining with asphalt to stop leaks."

The Harappans employed a variety of plumb bobs that reveal a system of weight based on a decimal scale. For example, a basic Harappan plumb bob weighs 27.584 grams. If we assign that a value of 1, other weights scale in at 0.5, .1., 2, .5, 2, 5, 10, 20 50, 100, 200, and 500. Archaeologists have found a “ruler” made of shell lines drawn 6.7 millimeters apart with a high degree of accuracy. Two of the lines are distinguished by circles and are separated by 33.5 millimeters or 1.32 inches. This distance is the

so-called **Indus inch.**

Harappan bricks contain no straw or binding material and are still in usable shape after five thousand years. Most interesting are their dimensions: while found in fifteen different sizes, their length, width, and thickness are always in the ration of 4:2:1.

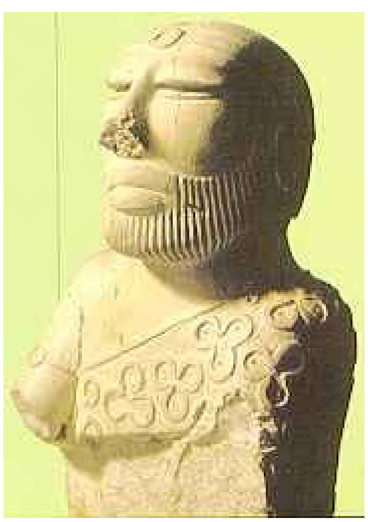
(source: **Lost Discoveries - Dick Teresi** p. 351-352 and 59 - 62).



In ancient India, as in Greece, there was much speculative thought about astronomy, mathematics, physics, and biology. But mathematics and mysticism were inextricably mixed in early Greek thought, and Greek belief in magic, divination and oracles was perhaps more pronounced than its counterpart in India.

It is therefore untrue to assert, as recent European writers particularly have done, that Greece was the home of pure science.

Both India and Greece, whilst having their own traditions, had direct and indirect effects on each other in science as they did in philosophy. In fact, long before the Greeks, the Indians had learned to employ the dialectic method to grasp empirical and transcendental truths, although in India, more perhaps than in ancient Greece or the modern West, reason and truth, logic and mysticism, the visible and invisible, have always been regarded as inseparable. The practical application of science to human affairs, was as poor in India as it was in any other ancient society. In fact, this was not achieved until the eighteenth century, until then science and technology developed separately. **When it did as in the case of Galileo Galilei, who was the first to employ the modern scientific method in its fullness, he incurred the wrath of the Church and was incarcerated by the Inquisition at the advanced age of seventy. There is hardly any parallel in India where a difference in interpretation either in metaphysics or scientific thought was so unkindly suppressed.**



The spirit of scientific enquiry and a rigorous correlation of cause and effect in explaining natural phenomenon were particularly evident in ancient India. The connection between Indian philosophy and medicine, mathematics, astronomy, and technology is, strangely enough seldom realized much less recognized.

Ancient Indians "measured the land, divided the year, mapped out the heavens, traced the course of the sun and the planets through the zodiacal belt, analyzed the constitution of matter, and studied the nature of birds and beasts, plants and seeds." Whilst in Western civilizations the interest has been increasingly focused on single sciences, in the Indian world the ontological viewpoint has been generally preferred, and it would appear that "in India, through all periods, the special sciences are rooted in and developed on the underlying cosmic concepts and presuppositions. This universal vision in India has never been lost.

India's contribution to the sciences of mathematics and medicine have been unique. In other sciences, especially linguistics, metallurgy, and chemistry, Indians made trail-blazing discoveries.

(source: **An Introduction to India - By Stanley Wolpert** p. 192).

The **Vedic Shulba Sutras** (fifth to eighth century B.C. E.) meaning **"codes of the rope,"** show that the earliest geometrical and mathematical investigations among the Indians arose from certain requirements of their religious rituals. When the poetic vision of the Vedic seers was externalized in symbols, rituals requiring altars and precise measurement became manifest, providing a means to the attainment of the unmanifest world of consciousness. "Shulba Sutras" is the name given to those portions or supplements of the Kalpasutras, which deal with the measurement and construction of the different altars or arenas for

religious rites. The word Shulba refers to the ropes used to make these measurements. Although Vedic mathematicians are known primarily for their computational genius in arithmetic and algebra, the basis and inspiration for the whole of Indian mathematics is geometry. Evidence of geometrical drawing instruments from as early as 2500 B.C.E. has been found in the Indus Valley.



The beginnings of algebra can be traced to the constructional geometry of the Vedic priests, which are preserved in the Shulba Sutras. Exact measurements, orientations, and different geometrical shapes for the altars and arenas used for the religious functions (yajnas), which occupy an important part of the Vedic religious culture, are described in the Shulba Sutras. Many of these calculations employ the geometrical formula known as the Pythagorean theorem.

This theorem (c. 540 B.C.E.), equating the square of the hypotenuse of a right angle triangle with the sum of the squares of the other two sides, was utilized in the earliest Shulba Sutra (the Baudhayana) prior to the eighth century B.C.E. Thus, widespread use of this famous mathematical theorem in India several centuries before its being popularized by Pythagoras has been documented. The exact wording of the theorem as presented in the Sulba Sutras is: "The diagonal chord of the rectangle makes both the squares that the horizontal and vertical sides make separately." The proof of this fundamentally important theorem is well known from Euclid's time until the present for its excessively tedious and cumbersome nature; yet the Vedas present five different extremely simple proofs for this theorem.

One historian, **Joseph Needham**, has stated, "Future research on the history of science and technology in Asia will in fact reveal that the achievements of these peoples contribute far more in all pre-Renaissance periods to the development of world science than has yet been realized."

Meticulous planning and architectural brilliance in the layout of the city are the established and striking features of the Harappan civilisation.

Recent excavations at the small township of Dholavira, in Kutch, Gujarat, have presented to the **world some of the oldest stadiums and sign board.**

One of the stadiums is huge. The multipurpose structure, with terraced seats for spectators, around 800 feet in length (around 283 metres) can accommodate as many as 10,000 persons. The other stadium is much smaller in size.

The dimensions of the town of Dholavira (777.1 metres in length and 668.7 meters in width) establishes that the Harappans had great knowledge of trigonometry. They were also mathematical experts as all the dimensions at the site are based on squares and cubes,

(source: **Oldest Harappan signboard at Kutch township** - timesofindia.com).

Ancient Indians already operated with a time span of astronomical proportions long before the earliest signs of natural science in ancient Greece. **It is undeniable that ancient Indian texts present astonishingly exact scientific calculations even by today's latest scientific standards, such as the speed of light, exact size of the smallest particles and the age of the universe.**

The **Surya Siddhanta**, a textbook on astronomy of ancient India - last compiled in 1000 BC, believed by Hindus to be handed down from 3000 BC by aid of complex mnemonic recital methods still known today - **computed the earth's diameter to be 7,840 miles, the distance earth - moon as 253,000 miles. These compare to modern measurements resp. as 7,926.7 miles and 252,710 miles for max. dist. moon-earth.**

Manu's texts in Sanskrit propounded evolution thousands of years before Lamarck & Darwin. "The first germ of life was developed by water and heat. Man will traverse the universe, gradually ascending and passing through the rocks, the plants, the worms, insects, fish, serpents, tortoises, wild animals, cattle, and higher animals. These are the transformations declared, from the plant to Brahma, which have to take place in the world."

Brihath Sathaka operates with divisions of the time of one day into:- 60 kalas or ghatika - 24 mins each. Subdivided into 60 vikala (24 secs.each) 60 para then into tatpara, then into vitatpara then into ima then into kasha.... the smallest unit, equal to approx. o.ooooooo3 of a second (one 300 millionth). This

smallest unit (3 X 10 -8 second) is surprisingly close to the life-spans of certain mesons and hyperons, according to some Western physicist who was interviewed on the BBC World Service in the early 1990s.

The 14th century 'Rigveda of the Sun' (dated by manuscript age only), says that the sun covers 2,202 yoganas in half a mimesa - which calculates as 300,000 metres a second, fairly exactly the speed of light.

(source: **Science, the Critical mind and Dissent - By Robert C Priddy**).



Francois Marie Arouet Voltaire (1694-1774) France's greatest writers and philosophers, was a theist, and a bitter critic of the Church said :

" It is very important to note that some 2,500 years ago at the least Pythagoras went from Samos to the Ganges to learn geometry...But he would certainly not have undertaken such a strange journey had the reputation of the Brahmans' science not been been long established in Europe....We have already acknowledged that arithmetic, geometry, astronomy were taught among the Brahmans. From time immemorial they have known the precession of the equinoxes and were in their calculation far closer to the real figure than the Greeks who came much later. Mr. Le Gentil (a French astronomer who spent several years in India) has with admiration acknowledged the Brahmans' science, as well as the immensity of time these Indians must have needed to reach a knowledge of which even the Chinese never had any notion, and which was unknown to Egypt and to Chaldea, the teacher of Egypt."

(source: **Fragments historiques sur l'linde** - By **Voltaire** p. 444 - 445.).

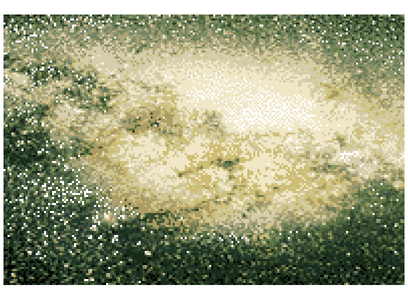
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Beginning of Indian Scientific Thought



The beginning of Indian scientific thought are traced to the same source as those of Indian metaphysics and religion, the Rig Veda. The Vedas, being essentially works of poetic imagination, cannot be expected to contain much spirit of scientific inquiry, yet there are remarkable flashes of intuitive conjecture and reason.
They explain the nature of the universe, of life, while admitting that Creation itself is the one unknowable mystery.
To the Vedic sages, creation indicated that point before which there was no Creator, the line between indefinable nothingness and something delineated by attributes and function, at least. Like the moment before the Big Bang Theory. These concepts preoccupy high wisdom, the Truth far removed from mere religion.

Indeed, in one of the most remarkable of the Vedic hymns - In the **Hymn of Creation (Rig Veda 10.129.3)** a searching inquiry as to the origin of the world is made; it is certainly the earliest known record of philosophic doubt.



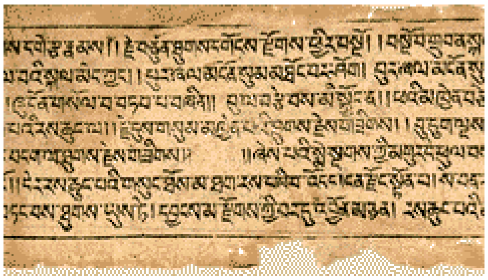
" There was not non-existent nor existent;
There was no realm of air, no sky beyond it.
What covered it, and where? and what gave shelter?
Was water there, unfathomed depth
of water?

Yet the Vedas go further, being philosophy, or really spiritual sciences, rather than myth. The hymn goes to say that in the beginning there was neither death nor immortality, nor day nor night. All that

existed was void and formless. Then arose, desire, the primal seed and germ of spirit. But,

Who verily knows and
who can declare it,
Whence it was born and
Whence comes this creation?

The gods are later than this
world's production
Who knows, then, whence it
first came into being?



Vedas are the most sophisticated, most profoundly beautiful, and most complete presentations of what Aldous Huxley termed the "perennial philosophy" that is at the core of all religions. In modern academia, of course, there is not supposed to be any "ancient wisdom". In this hymn, which contains the essence of monism, can be seen a representation of the most advanced theory of creation. The germ of free speculation and skepticism were already present in the Rig Veda.

(source: **The Empire of the Soul: Some Journeys into India - By Paul William Roberts** published by Riverhead Books ASIN: 1573226351 p 300-301).

The statue of Nataraja (dance pose of Lord Shiva) is a well known example for the artistic, scientific and philosophical significance of Hinduism.

Freedom was born in India. Doubt, the mother of freedom, was born with the **Rig Veda,** the most sacred scripture of the Hindus which has the following:

What are words, and what are mortal thoughts!
Who is there who truly knows and who can say,|
Whence this unfathomed world
And from what cause!

Freedom of the mind created the wondrous world of the intellect — the world of Hindu rishis, philosophers, poets and dramatists. It was the freedom of the mind and freedom of the senses which led to India's diversity and contributed to the richness of its civilization. No other civilization, not even that of the Greeks, could have enjoyed the freedom that we had. We have to remember, Socrates was forced to drink hemlock! The Inquisition burnt the Christian apostates at the stake and Islam beheaded dissenters.

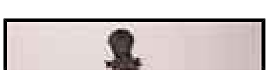
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Concept of Time

"After a cycle of universal dissolution, the Supreme Being decides to recreate the cosmos so that we souls can experience worlds of shape and solidity. Very subtle atoms begin to combine, eventually generating a cosmic wind that blows heavier and heavier atoms together. Souls depending on their karma earned in previous world systems, spontaneously draw to themselves atoms that coalesce into an appropriate body." - **The Prashasta Pada**.

***

As in modern physics, Hindu cosmology envisaged the universe as having a cyclical nature. The end of each kalpa brought about by Shiva's dance is also the beginning of the next. Rebirth follows destruction.



The transcendence of time is the aim of every Indian spiritual tradition. Time is often presented as an eternal wheel that binds the soul to a mortal existence of



ignorance and suffering. "Release" from time's fateful wheel is termed **moksha**, and an advanced ascetic may be called **kala-attita** (' he who has transcended time').

Hindus believe that the universe is without a beginning (**anadi**= beginning-less) or an end (**ananta** = end-less). Rather the universe is projected in cycles.

Time immemorial is measured in cycles called Kalpas. A Kalpa is a day and night for Brahma, the Lord of Creation. After each Kalpa, there is another Kalpa. Each Kalpa is composed of 1,000 Maha Yugas.

A Kalpa is thus equal to 4.32 billion human years. Kirtha Yuga or Satya yuga (golden or truth age) is 1,728,000 years; Treta yuga is 1,296,000 years; Dvapara yuga is 864,000 years; and Kali Yuga is 432,000 years. Total duration of the four yugas is called a **kalpa**. At the end of kalyuga the universe is dissolved by pralaya (cosmic deluge) and another cycle begins. Each cycle of creation lasts one kalpa, that is 12,000,000 human years (or 12,000 Brahma years).

One Maha Yuga is 4,32 million years.

Krita or Satya	golden age	1,728,000 years
Treta	silver age	1,296,000 years
Dvapara	copper age	864,000 years
Kali	iron age	432,000 years

A Brahma, or Lord of Creation, lives for one hundred Brahma years (each of made up of 360 Brahma days). After that he dies. So a Brahma lives for 36,000 Kalpas, or 36,000 x 2,000 x 4,30,000 human years – i.e., a Brahma lives for 311.4 trillion human years. After the death of each Brahma, there is a **Mahapralaya or Cosmic deluge**, when all the universe is destroyed. Then a new Brahma appears and creation starts all over again.

(source: **Am I a Hindu - by Ed Viswanathan** p. 292 - 293). For more on Yugas, refer to **One Cosmic Day of Creator Brahma**)

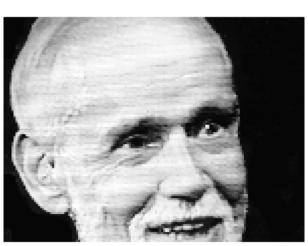
Time in Hindu mythology is conceived as a wheel turning through vast cycles of creation and destruction (pralaya), known as kalpa. In the words of famous writer, **Joseph Campbell:**

"The Hindus with their grandiose Kalpas and their ideas of the divine power which is beyond all human category (male or female). Not so alien to the imagery of modern science that it could not have been put to acceptable use."

According to **Guy Sorman,** visiting scholar at Hoover Institution at Stanford and the leader of new liberalism in France:

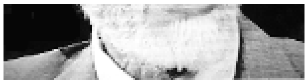
"Temporal notions in Europe were overturned by an India rooted in eternity. The Bible had been the yardstick for measuring time, but the infinitely vast time cycles of India suggested that the world was much older than anything the Bible spoke of. **It seem as if the Indian mind was better prepared for the chronological mutations of Darwinian evolution and astrophysics."**

(source: **The Genius of India - By Guy Sorman** (**'Le Genie de l'Inde'**) Macmillan India Ltd. 2001. ISBN 0333 93600 0 p. 195). For more on Guy Sorman refer to chapter **Quotes201_220**).(Refer to **Visions of the End of the World - By Dr. Subhash Kak** - sulekha.com).



Huston Smith a philosopher, most eloquent writer, world-famous religion scholar who practices Hatha Yoga. Has taught at MIT and is currently visiting professor at Univ. of California at Berkley. Smith has also produced PBS series. He has written various books, **The World's Religions**, "Science and Human Responsibility", and "The Religions of Man" says:

“Philosophers tell us that the Indians were the first ones to conceive of a true



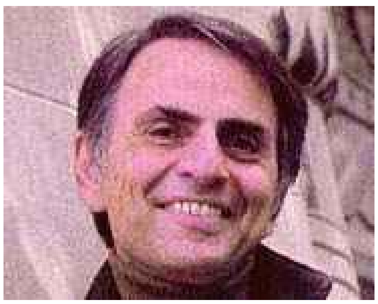
infinite from which nothing is excluded. The West shied away from this notion. The West likes form, boundaries that distinguish and demarcate. The trouble is that boundaries also imprison – they restrict and confine."

"India saw this clearly and turned her face to that which has no boundary or whatever." "India anchored her soul in the infinite seeing the things of the world as masks of the infinite assumes – there can be no end to these masks, of course. If they express a true infinity." And It is here that India's mind boggling variety links up to her infinite soul."

"India includes so much because her soul being infinite excludes nothing." **It goes without saying that the universe that India saw emerging from the infinite was stupendous."**

While the West was still thinking, perhaps, of 6,000 years old universe – India was already envisioning ages and eons and galaxies as numerous as the sands of the Ganges. The Universe so vast that modern astronomy slips into its folds without a ripple."

(source: **The Mystic's Journey - India and the Infinite: The Soul of a People – By Huston Smith**). For more on Huston Smith refer to chapter **Quotes41_60**).



Dr. Carl Sagan in his book **Broca's Brain: Reflections on the Romance of Science**, remarks:

"**Immanuel Velikovsky** (the author of **Earth in Upheaval**) in his book **Worlds in Collision**, notes that the idea of four ancient ages terminated by catastrophe is common to Indian as well as to Western sacred writing.

However, in the Bhagavad Gita and in the Vedas, widely divergent numbers of such ages, including an infinity of them, are given; but, more interesting, the duration of the ages between major catastrophes is specified as billions of years. .. "

"The idea that scientists or theologians, with our present still puny understanding of this vast and awesome cosmos, can comprehend the origins of the universe is only a little less silly than the idea that Mesopotamian astronomers of 3,000 years ago – from whom the ancient Hebrews borrowed, during the Babylonian captivity, the cosmological accounts in the first chapter of Genesis – could have understood the origins of the universe. We simply do not know.

The Hindu holy book, the Rig Veda (X:129), **has a much more realistic view of the matter:**

"Who knows for certain? Who shall here declare it?
Whence was it born, whence came creation?
The gods are later than this world's formation;
Who then can know the origins of the world?
None knows whence creation arose;
And whether he has or has not made it;
He who surveys it from the lofty skies,
Only he knows- or perhaps he knows not."

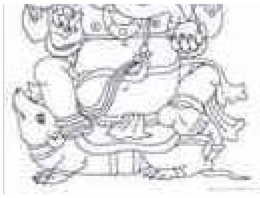
(source: **Broca's Brain: Reflections on the Romance of Science - By Carl Sagan** p. 106 - 137).

The theory of animal life and particularly of man was correctly understood by the ancient thinkers. The **Brihat Vishnu Purana** states that "the aquatic life precedes the monkey life" and that "the monkey life is the precursor of the human life." The same theory was explained in an interesting way by the dashavatara (ten incarnations). But evolution, as everything else, was the manifestation of the supreme spirit (Atman) as is testified by **Chandogya Upanishad.**

(source: **Ancient Indian History and Culture - By Chidambara Kulkarni** Orient Longman Ltd. 1974. p.268).



Hinduism is the only religion that propounds the idea of life-cycles of the universe. It suggests that the universe undergoes an infinite number of deaths and rebirths. Hinduism, according to **Carl Sagan**, *"...* is the only religion in which the time scales correspond... to those of modern scientific cosmology. Its cycles run from our ordinary day and night to a day and night of the Brahma, 8.64 billion years long, longer than



the age of the Earth or the Sun and about half the time since the Big Bang"

Long before **Aryabhata** (6th century) came up with this awesome achievement, apparently there was a mythological angle to this as well -- it becomes clear when one looks at the following translation of **Bhagavad Gita** (part VIII, lines 16 and 17),

"All the planets of the universe, from the most evolved to the most base, are places of suffering, where birth and death takes place. But for the soul that reaches my Kingdom, O son of Kunti, there is no more reincarnation. One day of Brahma is worth a thousand of the ages [yuga] known to humankind; as is each night."

Thus each **kalpa** is worth one day in the life of Brahma, the God of creation. In other words, the four ages of the **mahayuga** must be repeated a thousand times to make a "day ot Brahma", a unit of time that is the equivalent of 4.32 billion human years, doubling which one gets 8.64 billion years for a Brahma day and night. This was later theorized (possibly independently) by **Aryabhata** in the 6th century. The cyclic nature of this analysis suggests a universe that is expanding to be followed by contraction... **a cosmos without end. This, according to modern physicists is not an impossibility.**

(source: **Astronomy and Mathematics in Ancient India**).



Count Maurice Maeterlinck (1862-1949) was a Belgian writer of poetry, a wide variety of essays. He won the 1911 Nobel Prize for literature. In his book **Mountain Paths**, says:

"he falls back upon the earliest and greatest of Revelations, those of the Sacred Books of India with a Cosmogony which no European conception has ever surpassed."

(source: **Mountain Paths - By Maurice Maeterlinck**).

In Hindu thought, interspersed between linear, time-limited existences lie timeless intervals of non-existence. The creation hymn of the Hindus, Nasadiya-sukta of Rig-Veda, affirms an absolute beginning of things and describes the origin of the universe as being beyond the concepts of existence and non-existence

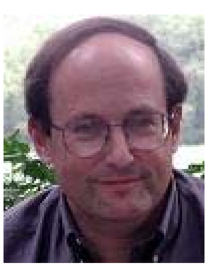
"The Hindu ... pictured the universe as periodically expanding and contracting and gave the name Kalpa to the time span between the beginning and the end of one creation. The scale of this space or time is indeed staggering. It has taken more than two thousand years to come up again with a similar concept."

Hindu culture had this unique vision of the infiniteness of time as well as the infinity of space. When modern astronomy deals with billion of years, Hindu creation concepts deal with trillions of years. **Vedanta** upholds the idea that creation is timeless, having no beginning in time. Each creation and dissolution follows in sequence. The whole cosmos exists in two states -- the unmanifested or undifferentiated state and the manifested or differentiated state.

(source: **The Origin of the Universe - By K B N Sarma** - sulekha.com).

John Bowle, categorically declares that **Plato was influenced by Indian ideas.**

(source: **A New Outline of World History - By John Bowle** p. 91).



Princeton University's **Paul Steinhardt** and Cambridge University's **Neil Turok**, have recently developed The Cyclical Model.

They have just fired their latest volley at that belief, **saying there could be a timeless cycle of expansion and contraction. It's an idea as old as Hinduism, updated for the 21st century. The theorists acknowledge that their cyclic concept draws upon religious and scientific ideas going back for millennia — echoing the "oscillating universe" model that was in vogue in the 1930s, as well as the Hindu belief that the universe has no beginning or end, but follows a cosmic cycle of creation and dissolution.**

(source: **Questioning the Big Bang - msnbcnews.com).**



Dick Teresi (?) author and coauthor of several books about science and technology, including **The God Particle**. He is cofounder of **Omni** magazine and has written:

"The big bang is the biggest-budget universe ever, with mind-boggling numbers to dazzle us – a technique pioneered by fifth-century A.D. **Indian cosmologists, the first to estimate the age of the earth at more than 4 billion years.** The cycle of creation and destruction continues forever, manifested in the **Hindu deity Shiva, Lord of the Dance,** who holds the drum that **sounds the universe's creation in his right hand and the flame that, billions of years later, will destroy the universe in his left.** Meanwhile Brahma is but one of untold numbers of other gods dreaming their own universes. The 8.64 billion years that mark a full day-and-night cycle in Brahma's life is about half the modern estimate for the age of the universe. The ancient Hindus believed that each Brahma day and each Brahma night lasted a kalpa, 4.32 billion years, with 72,000 kalpas equaling a Brahma century, 311,040 billion years in all. **That the Hindus could conceive of the universe in terms of billions."**

(source: **Lost Discoveries: The Ancient Roots of Modern Science - By Dick Teresi** p. 159 and 174 -212).

The Hindus, according to **Sir Monier-Williams,** were Spinozists more than 2,000 years before the advent of Spinoza, and Darwinians many centuries before Darwin and Evolutionists many centuries before the doctrine of Evolution was accepted by scientists of the present age.

The French historian **Louis Jacolliot** says, "Here to mock are conceit, our apprehensions, and our despair, we may read what **Manu** said, perhaps 10,000 years before the birth of Christ about Evolution:

' The first germ of life was developed by water and heat.' (Book I, sloka 8,9)
' Water ascends towards the sky in vapors; from the sun it descends in rain, from the rains are born the plants, and from the plants, animals.' (Book III, sloka 76).

(source: **Philosophy of Hinduism - By T C Galav** ISBN: 0964237709 p 17).



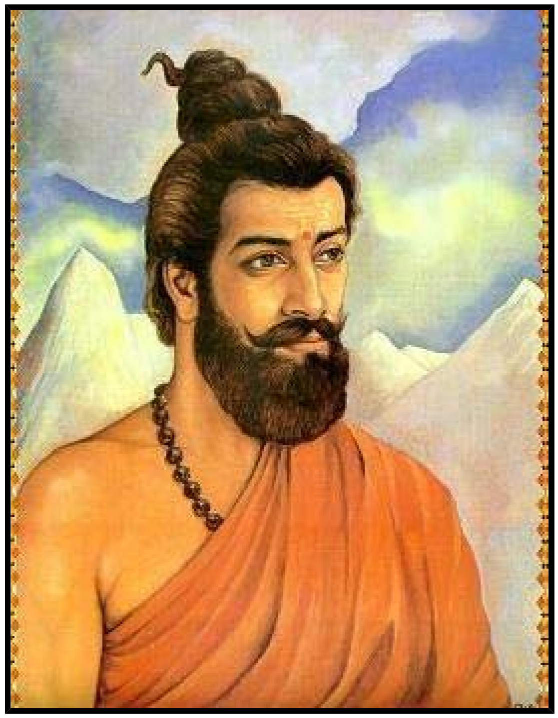
Sir John Woodroffe, (1865-1936) the well known scholar, Advocate-General of Bengal and sometime Legal Member of the Government of India. He served with competence for eighteen years and in 1915 officiated as Chief Justice. He has said:

"Ages before Lamarck and Darwin it was held in India that man has passed through 84 lakhs (8,400,000) of birth as plants, animals, as an "inferior species of man" and then as the ancestor of the developed type existing to-day.

"**The theory was not, like modern doctrine of evolution, based wholly on observation and a scientific enquiry into fact but was a rather (as some other matters) an act of brilliant intuition in which observation may also have had some part**."

(source: **Is India Civilized: Essays on Indian Culture - By Sir John Woodroffe** Publisher: Ganesh & Co. Publishers Date of Publication: 1922 p. 22).

Thus, in Hinduism, **science and religion are not opposed fundamentally**, as they often seem to be in the West, but are seen as parts of the same great search for truth and enlightenment that inspired the sages of Hinduism. Fundamental to Hindu concept of time and space is the notion that the external world is a product of the creative play of **Maya** (illusion).



Kapila Rishi

To the philosophers of India, however, Relativity is no new discovery, just as the concept of light years is no matter for astonishment to people used to thinking of time in millions of kalpas,

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"To the philosophers of India, however, Relativity is no new discovery, just as the concept of light years is no matter for astonishment to people used to thinking of time in millions of kalpas, (A kalpa is about 4,320,000 years). The fact that the wise men of India have not been concerned with technological applications of this knowledge arises from the circumstance that technology is but one of innumerable ways of applying it."

It is, indeed, a remarkable circumstance that when Western civilization discovers Relativity it applies it to the manufacture of atom-bombs, whereas Oriental civilization applies it to the development of new states of consciousness."

(source: **Spiritual Practices of India - By Frederic Spiegelberg** Introduction by **Alan Watts** p. 8-9).



The late scientist, **Carl Sagan**, asserts that the **Dance of Nataraja (Tandava)** signifies the cycle of evolution and destruction of the cosmic universe (Big Bang Theory). According to Carl Sagan, (1934-1996) astro-physicist, in his book **Cosmos** says:

"The Hindu religion is the only one of the world's great faiths dedicated to the idea that the Cosmos itself undergoes an immense, indeed an infinite, number of deaths and rebirths. **It is the only religion in which the time scales correspond, to those of modern scientific cosmology.**

"It is the clearest image of the activity of God which any art or religion can boast of." Modern physics has shown that the rhythm of creation and destruction is not only manifest in the turn of the seasons and in the birth and death of all living creatures, but also the very essence of inorganic matter.

For modern physicists, then, Shiva's dance is the dance of subatomic matter. Hundreds of years ago, Indian artist created visual images of dancing Shiva's in a beautiful series of bronzes. Today, physicist have used the most advanced technology to portray the pattern of the cosmic dance. Thus, the metaphor

of the cosmic dance unifies, ancient religious art and modern physics.

"The Hindu religion is the only one of the world's great faiths dedicated to the idea that the Cosmos itself undergoes an immense, indeed an infinite, number of deaths and rebirths. It is the only religion in which the time scales correspond, to those of modern scientific cosmology. Its cycles run from our ordinary day and night to a day and night of Brahma, 8.64 billion years long. Longer than the age of the Earth or the Sun and about half the time since the Big Bang. And there are much longer time scales still."

(source: **Cosmos - By Carl Sagan** ISBN: 0375508325 p. 213 -214).



Fritjof Capra (1939 -) Austrian-born famous theoretical high-energy physicist and ecologist wrote:

"Modern physics has thus revealed that every subatomic particle not only performs an energy dance, but also **is** an energy dance; a pulsating process of creation and destruction. The **dance of Shiva is the dancing universe**, the ceaseless flow of energy going through an infinite variety of patterns that melt into one another''. For the modern physicists, then Shiva's dance is the dance of subatomic matter. As in Hindu mythology, it is a continual dance of creation and destruction involving the whole cosmos; the basis of all existence and of all natural phenomenon. Hundreds of years ago, Indian artists created visual images of dancing Shivas in a beautiful series of bronzes. In our times, physicists have used the most advanced technology to portray the patterns of the cosmic dance."

(source: **The Tao of Physics: An Exploration of the Parallels Between Modern Physics and Eastern Mysticism - By Fritjof Capra** p. 241-245).



Dr. Heinrich Zimmer (1890-1943), the great German Indologist, a man of penetrating intellect, the keenest esthetic sensibility observed:

"In one of the **Puranic** accounts of the deeds of Vishnu in his **Boar Incarnation or Avatar**, occurs a **casual reference** to the cyclic recurrence of the great moments of myth. The Boar, carrying on his arm the goddess Earth whom he is in the act of rescuing from the depths of the sea, passingly remarks to her:

"Every time I carry you this way…."

For the Western mind, which believes in single, epoch-making, historical events (such as, for instance, the coming of Christ) this casual comment of the ageless god has a gently minimizing, annihilating effect."

(source: **The Myth and Symbols in India Art and Civilization – By Heinrich Zimmer** p. 18 and 152 - 155).



Professor Arthur Holmes (1895-1965) geologist, professor at the University of Durham. He writes regarding the age of the earth in his great book, **The Age of Earth** (1913) as follows:

"Long before it became a scientific aspiration to estimate the age of the earth, many elaborate systems of the world chronology had been devised by the sages of antiquity. **The most remarkable of these occult time-scales is that of the ancient Hindus, whose astonishing concept of the Earth's duration has been traced back to Manusmriti, a sacred book."**

When the Hindu calculation of the present age of the earth and the expanding universe could make Professor Holmes so astonished, the precision with which the Hindu calculation regarding the age of the entire Universe was made would make any man spellbound.

(source: **Hinduism and Scientific Quest - By T. R. R. Iyengar** p. 20-21).

The **Upanishads** **developed this spirit of inquiry, and traces of naturalistic and scientific thought in them are quite significant.** The Samkhya system, which has been described as the ruling philosophy of pre-Buddhist India and an orthodox system having its roots in the Upanishads, is essentially rational, anti-theistic, and intellectual. According to **Richard Garbe,** it was in Samkhya doctrine that complete independence and freedom of the human mind was exhibited for the first time in history. Samkhya, probably the oldest Indian philosophical system, furnished the background for the Yoga system, and the early Buddhist biography *Lalitavistara* includes both Samkhya and Yoga in the curriculum of study for the young Buddha. Samkhya is generally ascribed to Sage Kapila and Yoga to Sage Patanjali. Ideas of natural selection, atomic polarity and evolution.

Like in other ancient civilizations, **in Hindu India priests and scientists were often the same persons; the conflict between religion and reason is not the primitive condition** but a contingent historical development in post-classical Europe, paralleled to an extent by the stagnation of Muslim culture from the 12th century onwards. The Sankya philosophy of Kapila, in short, is devoted entirely to the systematic, logical, and scientific explanation of the process of cosmic evolution from that primordial Prakriti, or eternal Energy. There is no ancient philosophy in the world which was not indebted to the sankhya system of Kapila. The idea of evolution which the ancient Greeks and neo-Platonists had can be traced back to the influence of this Sankhya school of thought.

(source: **India and World Civilization - By D. P. Singhal** - Chapter V - **Naturalism and Science in Ancient India** - p.153 - 188).

Professor Edward Washburn Hopkins (1857-1932) Indologist, Chair of Sanskrit Studies of Yale, says:

"Plato is full of Sankhyan thought, worked out by him, but taken from Pythagoras. Before the sixth century B.C. all the religious-philosophical idea of Pythagoras are current in India (L. Schroeder, Pythagoras). If there were but one or two of these cases, they might be set aside as accidental coincidences, but such coincidences are too numerous to be the result of change. "

And again he writes: **"Neo-Platonism and Christian Gnosticism owe much to India. The Gnostic ideas in regard to a plurality of heavens and spiritual worlds go back directly to Hindu sources.** Soul and light are one in the Sankhyan system, before they became so in Greece, and when they appear united in Greece it is by means of the thought which is borrowed from India. The famous three qualities of the Sankhyan reappear as the Gnostic 'three classes.'

(source: **Religions of India - By Edward Washburn Hopkins** p. 559-560).

Some sources even credit **Pythagoras with having traveled as far as India in search of knowledge,** which may explain some of the close parallels between Indian and Pythagorean philosophy and religion. These parallels include:

a. a belief in the **transmigration of souls**;
b. the theory of four elements constituting matter;
c. the reasons for not eating beans;
d. the structure of the religio-philosophical character of the Pythagorean fraternity, which resembled Buddhist monastic orders; and
e. the contents of the mystical speculations of the Pythagorean schools, which bear a striking resemblance of the Hindu **Upanishads**.

According to Greek tradition, Pythagoras, Thales, Empedocles, Anaxagoras, Democritus and others undertook journey to the East to study philosophy and science. By the time Ptolmaic Egypt and Rome's Eastern empire had established themselves just before the beginning of the Common era, Indian civilization was already well developed, having founded three great religions – Hinduism, Buddhism and Jainism – and expressed in writing some subtle currents of religious thought and speculation as well as fundamental theories in science and medicine.

(source: **The crest of the peacock: Non-European roots of Mathematics - By George Gheverghese Joseph** p. 1 - 18). For more refer to chapter on **India and Greece**).



A 9th century Hindu scripture, The **Mahapurana by Jinasena** claims the something as modern as the following: (translation from [5])

"Some foolish men declare that a Creator made the world. The doctrine that the world was created is ill-advised, and should be rejected. If God created the world, where was he before creation?... How could God have made the world without any raw material? If you say He made this first, and then the world, you are faced with an endless regression... Know that the world is uncreated, as time itself is, without beginning and end. And it is based on principles."

(source: **Astronomy and Mathematics in Ancient India**). (Refer to **Visions of the End of the World - By Dr. Subhash Kak** - sulekha.com).

Modern people divide the day into 24 hours, the hour - into 60 minutes, the minute - into 60 seconds. **Ancient Hindus divided the day in 60 periods, lasting 24 minutes each, and so on and so forth. The shortest time period of ancient Hindus made up one-three-hundred-millionth of a second.**

(source: **Ancient nuclear blasts and levitating stones of Shivapur - By Alexander Pechersky - pravda.ru.com**).

Speed of Light:

Sayana (c. 1315-1387) was a minister in the court of **King Bukka I of the Vijayanagar Empire in South India**; he was also a great Vedic scholar who wrote extensive commentaries on several ancient texts. In his commentary on the fourth verse of the hymn 1.50 of the **Rig Veda** on the sun, he says:

Tatha cha smaryate yojananam sahasre dve dve shate dve cha yogane ekena nimishardhena kramamana namo ‘stu ta iti

Thus it is remembered: (O Sun), bow to you, you who travers 2,202 yojanas in half a minute.

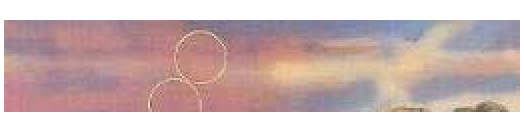
The Puranas define 1 nimesha to be equal to 16/75 seconds. 1 yojana is about 9 miles. Substituting in Sayana’s statement we get 186,000 per second.

Sayana’s statement was printed in 1890 in the famous edition of **Rig Veda edited by Max Muller**, the German Sanskritist . He claimed to have used several three or four hundred year old manuscripts of Sayana’s commentary, written much before the time of **Romer**. Further support for the genuineness of the figure in the ancient book comes from one of the earliest Puranas, the Vayu, conservatively dated to at least 1,500 years old. The **Puranas** speak of the creation and destruction of the universe in cycles of 8.64 billion years, that is quite close to currently accepted value regarding the time of the big bang.

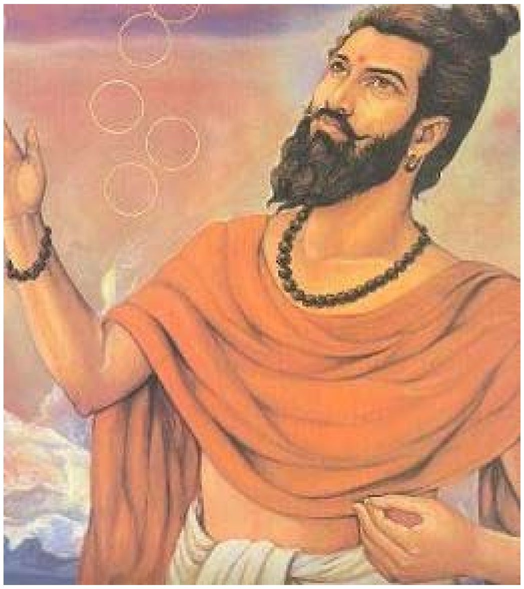
(source: **The Wishing Tree - By Subhash Kak** p. 75 - 77 and **Sayana's Astronomy - By Subhash Kak**).

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Physics



In the realm of physics, remarkable contributions have been made by Indian scientists. Some hint at the theory may be contained in the views of **Uddalaka Aruni,** preserved in the



Chandogya Upanishad. Uddalaka says: "matter was at first a chaotic mass, like the juices of various trees indiscriminately blended together in honey. In order to develop names-and-forms, to discriminate things from one another, or to set them in order, the universal spirit came not in its universal form but as the living, principle, and entered into Fire, Water and Earth. After separating their component but qualitatively distinct parts (dhatus), it made numerous new combinations of them. By propounding the theory of combination and separation of particles, Uddalaka anticipated the atomic theory of Kannada.'

Kanaada, the founder of the **Vaisesika system of philosophy**, expounded that the entire matter in this world consists of atoms as many in kind as the various elements. Kanaada's atom would then correspond to the modern atom. He said:

"The cause of creative motion is believed to be adrsta, unseen moral force which guides the destiny of souls according to their karma and requires them to be provided with properly equipped bodies and an appropriate objective world for the experience of pleasure and pain. It is due to the operation of this metempirical force that atoms start moving to get together in order that they may be integrated into countless varieties of things."

Some **Jain** thinkers went a step further. They thought that all atoms are the same kind and variety emerged because they entered into different combinations. Kanaada taught that light and heat are variations of the same reality.

Vacaspati interpreted light as composed of minute particles emitted by substances and striking the eyes. This is a clear anticipation of the corpuscular theory of light, which was proposed by Newton but rejected till the discovery of the proton.

Modern physics confirmed that the sun's rays travel in a curved way, but not in a straight line. Our ancestors told that the sun's chariot was drawn by seven horses tied by snakes. As the movements of the snakes are crooked and curved, so also the sun's ray. The phenomenon is described in a metaphysical poetic line bhujagana mita sapta turaga. The chapter on light says that there are seven colors in the white ray of the sun. **Artharveda** says that there are seven types of sun's rays, **sapta surayasya rasmayah.**

The law of gravitation discovered by Brahmagupta anticipated Newton by declaring **"all things fall to the earth by law of nature; for it is the nature of the earth to attract and keep things."**

(source: **Hinduism and Scientific Quest** - **By T R. R. Iyengar** p. 153-154 and **History of Science and Technology in Ancient India** **- by Debiprasad Chattopadhya** volume II p. 297-299). For more information refer to the chapter '**Advanced Concepts**).

Kannada was an expounder of the law of causation and of the atomic theory. He classified all the objects of creation into nine elements, namely: earth, water, light, wind, ether, time, space, mind and soul. According to his theory every object of creation is made of atoms, which in turn are joined with each other to form molecules. His statement ushered in the Atomic theory for the first time in the world, early 2500 years before John Dalton. Kanaada has also described the dimension and motion of atoms and their chemical reactions with each other.

T. N. Colebrooke, has said: "Compared to the scientists of Europe, Kanaada and others Indian scientists were the global masters in this field."

(source: **Calendar 2002 - VHP of America**).

Umasvati, who lived in the first century A.D. suggested that atoms of opposite qualities alone combined and the atoms attracted or repelled as they were heterogeneous or homogenous. Commenting on these theories, A. L Basham remarks: "Indian atomic theories were not of course, based on experiment, but on

intuition and logic..."

Gravity was considered a peculiar cause of primary descent or falling...In the absence of counter-balancing cause, as adhesion, velocity or some act of volition, descent results from this quality. Thus a coconut is withheld from falling by adhesion of the foot-stalk, but this impediment ceasing on maturity of the fruit, it falls. The penetrative diffusion of liquid was explained by capillary motion and the conduction of water in pipes was said to be due to the pressure of air. They were familiar with an accurate method of calculating velocity which facilitated the measurement of the relative pitch of musical tones with great precision. They anticipated the Pythagorean law of vibration of stretched strings. viz. the number of vibrations varies inversely as the length of the string.



The believed that energy was indestructible and thus anticipated the law of conservation and energy. Heat and light were viewed as only different forms of the same essential substance. One of the scientists succeeded in suggesting a scientific explanation of the phenomenon of ebullition and rarefaction in evaporation. They were familiar with refraction and chemical effects of light rays, causes of translucency, opacity and shadows. They evolved the formula that the angle of incidence was equal to the angle of reflection.

They discovered that a magnet possessed the power of attracting iron. **Bhoja**, a writer of the eleventh century, therefore, suggested that iron should not be used in the construction of a ship to avoid the danger of being drawn into a magnetic field by magnetic rocks. **They also discovered the mariner's compass centuries before its discovery in Europe.** (for more information refer to chapters **War in Ancient India** and **Seafaring in Ancient India**). **It was called matsya-yantra and consisted of an iron fish which floated in a vessel of oil and pointed at the North.**

(source: **Main Currents in Indian Culture - By S. Natarajan** p. 68 - 69 Indo-Middle East Cultural Studies Hyderabad 1960).

The Indians came closest to modern ideas of atomism, quantum physics, and other current theories. India developed very early, enduring atomist theories of matter. Possibly Greek atomistic thought was influenced by India, via the Persian civilization. **The Rig-Veda, is the first Indian literature to set down ideas resembling universal natural laws. Cosmic law is connected with cosmic light, with gods, and, later, specifically with Brahman."** It was the Vedic Aryans... who gave the world some of the earliest philosophical texts on the makeup of matter and the theoretical underpinnings for the chemical makeup of minerals. Sanskrit Vedas from thousands of years before Christ implied that matter could not be created, and that the universe had created itself. Reflecting this, in his **Vaiseshika** philosophy, **Kanada** (600 B. C) claimed that elements could not be destroyed. Kanada's life is somewhat a mysterious, but his name is said to mean "one who eats particle or grain" likely referring to his theory that basic particles mix together as the building blocks for all matter. Two, three, four, or more of these elements would combine, just as we conceive of atoms doing. The Greeks would not stumble on this concept for another century."

(source: **Lost Discoveries: The Ancient Roots of Modern Science - By Dick Teresi** p. 1 - 8 and 159 and 174 -239). For more on Dick Teresi refer to chapters **Quotes301_320**, **GlimpsesVI** and **GlimpsesVII**).

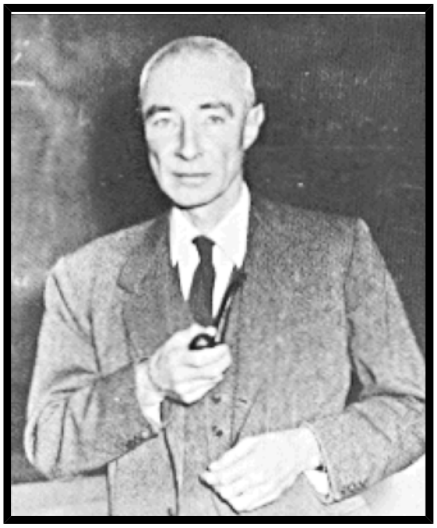
Historian **A. L. Basham** has written:

"The atomic theories of ancient India are brilliant imaginative explanations of the physical structure of the world..."

Further progress was made in knowing the qualities and functions of earth, water, heat, sound etc. Especially in sound the ancient Indians reached great heights very early. The octave was divided into 22 shrutis (quarter-tones) and their proportions were measured with great accuracy. Their love of accuracy and precision is testified by their tables of weights, and measures. The measurement of time was, for example, based on the unit of time taken by a wink (nimisha).

(source: **Ancient Indian History and Culture - By Chidambara Kulkarni** Orient Longman Ltd. 1974. p. 272).

J R Oppenheimer and Atom bomb in modern times



Only seven years after the first successful atom bomb blast in New Mexico, **Dr. Oppenheimer of the Manhattan Project**, who was familiar with ancient Sanskrit literature, was giving a lecture at Rochester University. During the question and answer period a student asked a question to which Oppenheimer gave a strangely qualified answer:

Student: Was the bomb exploded at Alamogordo during the Manhattan Project the first one to be detonated?

Dr. Oppenheimer: "Well -- yes. In modern times, of course.

Charles Berlitz goes on to quote a number of passages from the Mahabharata that describe the impact of a weapon that I suspect must be the brahmaastra, although he neither names the weapon nor cites those sections of the text from which his quotations are drawn (he lists Protap Chandra Roy's translation of 1889 in his bibliography):...a single projectile Charged with all the power of the Universe.

An incandescent column of smoke and flame As bright as ten thousand Suns Rose in all its splendor......it was an unknown weapon, An iron thunderbolt, A gigantic messenger of death, Which reduced to ashes. The Entire race of the Vrishnis and the Andhakas....the corpses were so burned As to be unrecognizable. Their hair and nails fell out; Pottery broke without apparent cause, And the birds turned white. After a few hours all foodstuffs were infected......To escape from this fire. The soldiers threw themselves in streams to wash themselves and their equipment...

One is reminded of the yet unknown final effect of a super-bomb when we read in the **Ramayana** of a projectile:

...So powerful that it could destroy
The earth in an instant -
A great soaring sound in smoke and flames...
And on it sits Death...

(source: **Doomsday 1999 - By Charles Berlitz** Doubleday ASIN: 038515982X p. 118-122). For more on Oppenheimer, refer to **Quotes21_40** and **GlimpsesX**).

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Mathematics - The Language of Science

"Like the crest of a peacock, like the gem on the head of a snake, so is mathematics at the head of all knowledge."

– Vedanga Jyotisa.

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In mental abstraction and concentration of thought the Hindus are proverbially happy. Apart from direct testimony on the point, the literature of the Hindus furnishes unmistakable evidence to prove that the ancient Hindus possessed astonishing power of memory and concentration of thought. The science of mathematics, the most abstract of all sciences, must have an irresistible

fascination for the minds of the Hindus.

The great German critic, **Schlegel** wrote in his **History of Literature**, p. 123: "The decimal cyphers, the honor of which, next to letters the most important of human discoveries, has, with the common consent of historical authorities, been ascribed to Hindus."

Mathematics is the science to which Indians have contributed the most. Our decimal system, place notation, numbers 1 through 9, and the ubiquitous 0, are all major Indian contributions to world science. Without them, our modern world of computer sciences, earth-launched satellites, microchips, and artificial intelligence would all have been impossible.

(source: **An Introduction to India - By Stanley Wolpert** p. 194).



Hermann Hankel (1839 - 1873) born in Halle, Germany in his **History of Mathematics** says:

" It is remarkable to what extent Indian Mathematics enters into the Science of our time"

(source: **Is India Civilized? - Essays on Indian Culture - By Sir John Woodroffe** Ganesh & Co. Publishers 1922 p. 182).

The earliest recorded Indian mathematics was found along the banks of the Indus. Archaeologists have uncovered several scales, instruments, and other measuring devices. The Harappans employed a variety of plumb bobs that reveal a system of weights 27.584 grams. If we assign that a value of 1, other weights scale in at .05, .1, .2, .5, 2, 5, 10, 20, 50, 100, 200 and 500. These weights have been found in sites that span a five-thousand-year period, with little change in size.

Archaeologists also found a **"ruler"** made of shell lines drawn 6.7 millimeters apart with a **high degree of accuracy**. Two of the lines are distinguished by circles and are separated by 33.5 millimeters, or 1.32 inches. This distance is the so-called Indus inch.

(source: **Lost Discoveries - Dick Teresi** p. 59).

Fascination with numbers has been an abiding characteristic of Indian civilization, not only large numbers but very small ones as well. Operations with zero attracted the interest of both Bhaskaracharya (b. 1114) and Srinivas Ramanujan (1887-1920).



In **Ramayana**, the great Indian epic, there is a description of two armies facing, each other. The size of the larger army led by **Rama** is given as follows in a 17th century translation of the epic by **Kottayam Kerala varma Thampuran**:

Hundred hundred thousands make a Crore
Hundred thousand crores make a Sankhu
Hundred thousand sankhus make a Maha-sankhu
Hundred thousand maha-sankhus make a Vriundam
Hundred thousand vriundam make a Maha-vriundam
Hundred thousand maha-vriundams make a Padmam
Hundred thousand padmams make a Maha-padmam
Hundred thousand maha-padmams make a Kharvam
Hundred thousand kharvams make a Maha-kharvam
Hundred thousand maha-kharvams make a Samudra
Hundred thousand samudras make a Maha-ougham.

The importance of number names in the evolution of the decimal place value notation in India cannot be exaggerated. The word-numeral system was the logical outcome of proceeding by multiples of ten. Thus, in an early system, 60,799 is denoted by the Sanskrit word sastim (60), shsara (thousand),

sapta (seven) satani (hundred), navatim (nine ten times) and nava (nine). **Such a system presupposes a scientifically based vocabulary of number names in which the principles of addition, subtraction and multiplication are used.** It requires:

1. the naming of the first nine digits (eka, dvi, tri, catur, pancha, sat, sapta, asta, nava);
2. a second group of nine numbers obtained by multiplying each of the nine digits in 1 by ten (dasa, vimsat, trimsat, catvarimsat, panchasat, sasti, saptati, astiti, navati): and
3. a group of numbers which are increasing integral powers of 10, starting with 10^2 (satam sagasara, ayut, niyuta, prayuta, arbuda, nyarbuda, samudra, Madhya, anta, parardha…).

To understand why word numerals persisted in India, even after the Indian numerals became widespread, it is necessary to recognize the importance of the oral mode of preserving and disseminating knowledge. An important characteristic of written texts in India from times immemorial was the sutra style of writing, which presented information in a cryptic form, leaving out details and rationale to be filled in by teachers and commentators. In short pithy sentences, often expressed in verse, the sutras enabled the reader to memorize the content easily.

(source: **The crest of the peacock: Non-European roots of Mathematics - By George Gheverghese Joseph** p.401 - 403).

In the Vedic age, India was ahead of the rest in mathematics and astronomy. Thus, the geometry of the **Shulba Sutras** (T**he Rules of the Cord**), geometrical appendices to the manuals of ritual (Shrauta Sutras) include the oldest known formulation of the theorem named after Pythagoras, developed in the context of Vedic altar-building. The first decimal system and the oldest names of "astronomical" numbers such as quadrillions and quintillions. Arabs still call the decimal system **rakmu 'l-Hind**, from Hind, "India."

(source: **Mathematics as Known to the Vedic Samhitas - By M. D. Pandit** p. 20).



Highly intellectual and given to abstract thinking as they were, one would expect the ancient Indians to excel in mathematics. Ancient Indians developed a system of mathematics far superior, to that of the Greeks. Ancient Vedic mathematicians devised sutras for solving mathematical problems with apparent ease. Among the most vital parts of our heritage are the numerals and the decimal system. The miscalled "Arabic" numerals are found on the Rock Edicts of Ashoka (250 B.C.), a thousand years before their occurrence in Arabic literature. **Hindsaa (numerals) in Arabic means from India.** **Jawaharlal Nehru** has said, " The clumsy method of using a counting frame and the use of Roman and such like numerals had long retarded progress when the ten Indian numerals, including the zero sign, liberated the human mind from these restrictions and threw a flood of light on the behavior of numbers."

(source: **The Discovery of India - By Jawaharlal Nehru** Oxford University Press. 1995 p. 216).

Vedanga Jyotisa says "As are the crests on the heads of peacocks, as are the gems on the hoods of the snakes so is the **ganita** (Mathematics) **at the top of the sciences known as Vedanga.** In this period, ganita is a comprehensive term which included arithmetic, algebra and astronomy. Geometry was also investigated but was placed in a different general science known as kalpa. Indians were the first to use the decimal either to increase or decrease the value of the figure which was presided by Laplace, the great French mathematician. Indians were the first to use the 'zero' as a symbol in mathematics. They invented the present numerical system. India teachers taught arithmetic and algebra, Vedic Sulva Sutras were earlier than the Alexandrian geometry of Hero. The earliest available work was Bakshali Manuscript. **Ganita-Sara-Sangraham** of Mahavira acarya who lived between Brahmagupta and Bhaskaracharya.

The 'Pythagoras theorem' which stated in **Sulva Sutras** by **Baudhayana's** (6th century C. E): "The diagonal of a rectangle produces both areas, which its length and breadth produce separately." Arya Bhatta discovered the method of finding out the areas of a triangle, a trapezium and a circle. The approximate value of an 'irrational number' i.e. 2 (dvikarani) (1.143256) and 3 (1.7320513) can be

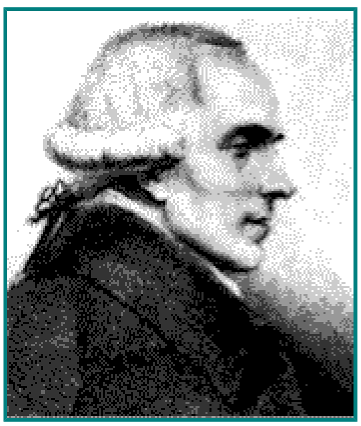
obtained, Baudhayana and Apastamba.

In the geometry of the circle, "Arybhatta I" gave a value for pi (tyajya) which is correct to the four decimal places in a sloka (Sankara Varman's treatise on astronomy, Sadratnamala) theorems and their deductions:

"Lemma of **Brahmagupta** for integral solution or the indeterminate equation of second degree. **John Pell** (1611-1685) **discovered this in the 17th century. Indians discovered it a 1,000 years earlier.**

(source: **Hinduism and Scientific Quest** - **By T R. R. Iyengar** p. 151-152).

The most fundamental contribution of ancient India in mathematics is the invention of decimal system of enumeration, including the invention of zero. The decimal system uses nine digits (1 to 9) and the symbol zero (for nothing) to denote all natural numbers by assigning a place value to the digits. The Arabs carried this system to Africa and Europe. The **Vedas and Valmiki Ramayana** used this system, though the exact dates of these works are not known. MohanjoDaro and Harappa excavations (which may be around 3000 B.C. old) also give specimens of writing in India. Aryans came 1000 years later, around 2000 B.C. Being very religious people, they were deeply interested in planetary positions to calculate auspicious times, and they developed astronomy and mathematics towards this end. They identified various **nakshatras** (constellations) and named the months after them. They could count up to 10^{12}, while the Greeks could count up to 10^4 and Romans up to 10^8. Values of irrational numbers were also known to them to a high degree of approximation. Pythagoras Theorem can be also traced to the Aryan's Sulbasutras. These Sutras, estimated to be between 800 B.C. and 500 B.C., cover a large number of geometric principles.



Said the great and magnanimous **Pierre Simon de Laplace,** (1749-1827) French mathematician, philosopher, and astronomer, a contemporary of Napoleon :

" It is India that gave us the ingenious method of expressing all numbers by ten symbols, each receiving a value of position as well as an absolute value, a profound and important idea which appears so simple to us now that we ignore its true merit. But its very simplicity, the great ease which it has lent to all computations, puts our arithmetic in the first rank of useful inventions, and we shall appreciate the grandeur of this achievement the more when we remember that it escaped the genius of Archimedes and Appollnius, two of the greatest men produced by antiquity."

(source: **The Discovery of India - By Jawaharlal Nehru** Oxford University Press. 1995 p. 217)

The decimal system was known to Aryabhatta and Brahmagupta long before its appearance in the writings of the Arabs and the Syrians; it was adopted by China from Buddhist missionaries; and Muhammad Ibn Musa al-Khwarazni, the greatest mathematician of his age (ca 850 A.D.), seems to have introduced it into Baghdad.

Zero, this most modest and most valuable of all numerals is one of the subtle gifts of India to mankind. The earliest use of the zero symbol, so far discovered, is in one of the scriptural books dated about 200 B.C. The zero, called **shunya** or nothing, was originally a dot and later it became a small circle. It was considered as a number like any other. **Professor G. B. Halsted**, in his book **' Mathematics for the Million'** (London 1942) thus emphasizes the vital significance of this invention:

"The importance of the creation of the zero mark can never be exaggerated. This giving to airy nothing, not merely a local habitation and a name, a picture, a symbol but helpful power, is the characteristic of the Hindu race whence it sprang. It is like coining the Nirvana into dynamos. No single mathematical creation has been more potent for the general on-go of intelligence and power." It was India that first domesticated zero, through the Hindu familiarity with the concepts of infinity and the void. Neither pagan Rome nor the Christian Europe of the Middle Ages had any truck with it. It's all, as the Hindus knew, a play between the void and the absolute.

Yet another modern mathematician has grown eloquent over this historic event. **Dantzig** in his 'Number' writes:

"This long period of nearly five thousand years saw the rise and fall of many a civilization, each leaving behind a heritage of literature, art, philosophy, and religion. But what was the net achievement in the field of reckoning, the earliest art practiced by man? An inflexible numeration so crude as to make progress well nigh impossible, and a calculating device so limited in scope that even elementary calculations called for the services of an expert.....When viewed in this light the achievements of the unknown Hindu, who sometime in the first centuries of our era discovered the principle of position, assumes the importance of a world event."

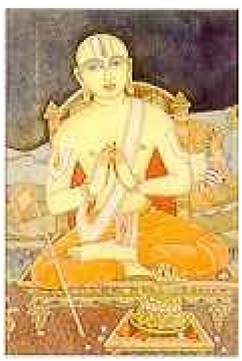
Dantzig is puzzled at the fact that the great mathematicians of Greece did not stumble on this discovery.

"Is it that the Greeks had such a marked contempt for applied science, leaving even the instruction of their children to the slaves? But if so, how is it that the nation that gave us geometry and carried this science so far did not create a rudimentary algebra? that corner-stone of modern mathematics, also originated in India, and at about the same time that positional numeration did?"

(source: **The Discovery of India - By Jawaharlal Nehru** Oxford University Press. 1995 p. 218)

The Unsung Mathematician:

An important Mathematics book prescribed by the **New York State Education Department** acknowledges the debt in the following words:



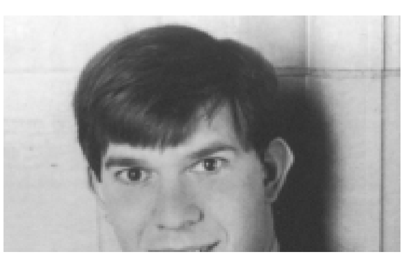
"The Western world owes a great deal to India for a simple invention. It was developed by an unknown Indian more than 1500 years ago. Without it most of the great discoveries and inventions (including computers) of western civilization would never have come about. This invention was the decimal system of numerals - nine digits and a zero. The science and technology of today (including the computers) could not have developed if we had only the Roman system of numerals. That system is too clumsy to be used as a scientific too. Today we take the decimal system for granted. We don't think about how brilliant the man who invented zero must have been. Yet without zero we could not assign a place value to the digits. That ancient mathematician, whoever, he was, deserves much honor."

Indians also made advances in other areas of mathematics. Very early in their history they developed a simple system of geometry. This system was used to plan outdoor sites for Indian religious ceremonies. Indians also added to our knowledge of even more complicated branches of mathematics such as trigonometry and calculus. They studied these branches of mathematics in order to apply them to astronomy."

(source: **Harry Shor and Gloria Meng, Exploring Algebra**).

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju.

Refer to **Visualizing Indian heritage Digital Library Metaphor – By Nagnath R Ramdasi - CDAC.**



Charles Seife, a journalist with Science magazine, has also written for New Scientist, Scientific American, The Economist, Science, Wired UK, The Sciences, and numerous other publications. He holds an M.S. in mathematics from Yale University and his areas of research include probability theory and artificial intelligence. He is a mathematician and science writer, author of **Zero: The Biography of a Dangerous Idea** says:



"Perhaps no one has embraced nothing as strongly as the Indians who, Seife notes, **"never had a fear of the infinite or of the void." Hinduism has embedded within it, a complex philosophy of nothingness, seeing everything in the world as arising from the pregnant void, known as Sunya**.

"**The ultimate goal of the Hindu was to free himself from the endless cycle of pain found in continual reincarnation and reconnect with the Nothingness that is the source and fundament of the All.** For Indians, the void of Sunya was the very font of all potential; nothingness was liberation. No surprise then that it is from this sophisticated culture that we inherit the mathematical analog of nothing, zero. Like Sunya, zero is a kind of place holder, a symbol signifying a pregnant space where any other number might potentially reside."

(source: **Zero: The Biography of a Dangerous Idea: It's weird, it's counterintuitive and the Greeks hated it. Why did the Church reject the use of zero?**
http://www.calendarlive.com/top/1,1419,L-LATimes-Books-X!ArticleDetail-26133,00.html
http://www.salon.com/books/review/2000/03/03/seife/index.html).

Lancelot Thomas Hogben (1895-1975) English zoologist and geneticist, has written:

"In the whole history of Mathematics, there has been no more revolutionary step than the one which the Hindus made when they invented the sign '0' for the empty column of the counting frame."

(source: **Mathematics for the Million - By Lancelot Thomas Hogben** p. 47).

The **concept of Debits and negative numbers** originated in India, and why were they not accepted until recently? It was much more than 2000 years ago. It wasn't accepted elsewhere because the Church did not think it possible.

The paper of **Reuben Burrow** (1798-1868) "**A Proof that the Hindus had the Binomial Theorem."** (published in 1790) Asiatic Researches 2 (1790): 487-97 is more proof for us that the western world was aware of the Indian achievement in the field of combinational mathematics. Then, the problem would be one of explaining how the so called 'Pascal's triangle' continues to bear his name, or how the British reference books like the Encyclopedia Britannica persisted (till well into the 20th century) in crediting Newton with the discovery of the binomial theorem.

(source: **India Through The Ages: History, Art Culture and Religion - By G. Kuppuram** p. 672-673).

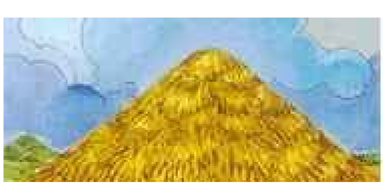
The Hindus knew mathematics much early. In the **Rig Veda** (2-18, 4 to 6), there are references to 'two', 'four', 'eight', 'ten.'

Aa dvabhyam haribhyamindryahya
chaturbhirashadabhi rhuya manah ashtabhirdashabhih

Also in **Vajasaneya Samhita** (17.2), there is the passage referring to 1, 10, 100, 1000 etc.

Eka cha dasha cha dasha cha shatam cha shatam cha
sahasram cha sahasram cha yutam cha ayutam cha
niyutam cha niyutam cha prayutam cha. Etc.

In **Mahabharata** there are references to addition and subtraction. Adhikam (more), Unam (less), Shesham (remaining), multiplication and division are indicated. For example, "60 thousand camels and twice the number of horses" are referred to.



In Rig Veda (10.62.7), Nabhanedishta praises King Savarni for giving in charity one thousand cows, who had the figure 8 on their ears and so were called Ashta Karni. It seems that gambling was very common in the Vedic days, and it involved dices and numbers. According to Yajur Veda, Vajasneya Samhita (4.3,3), in the Rajasuya sacrifice, five was called Abhiburasi. In another kind of gambling, the dice (Aksha) used four names



of the four Ages namely Krita, Treta, Dvapar and Kali and they were numbered 4, 3, 2 and 1. The numbers from one to one thousand billion are found in the **Vajasneya Samhita** and also in Taitteriya, Maitrayani and Kathaka Samhitas.

In **Sama Veda**, in the 25th Brahmana, there is a reference to how much fees (dakshina) should be given to a priest in sacrifice (Yajna). It may be at least 12 (Krishnala) milligrams of gold, and doubling the figure, it can go up to 3,93,216.

The system they adopt in giving page numbers in old manuscripts in Malabar and in Andhra was to have 34 digits of consonants from Ka to La and then to have the next 34 digits by adding vowels Kaa to Laa. They can number pages upto 408 (34 x 12). Burma also had the same system for **pagination.**

(source: **Hinduism: Its Contribution to Science and Civilization - By Prabhakar Balvant Machwe** p. 10 -14).

The Notion of Infinity and zero:

There is a beautiful definition of the infinite in the following line of a Vedic mantra, which forms the introductory verse to the **Isa Upanishad**:

It says: Take the whole (Infinite Brahman) from the whole, and the whole still remains. This is almost like the mathematician, Cantor's definition of infinity.

The very names of the numerals are of Sanskrit origin. **Professor Arthur Macdonell** says in his **A History of Sanskrit Literature**: "During the eighth and ninth centuries, the Indians became the teachers in arithmetic and algebra of the Arabs, and through them of the nations of the west. Thus, though we call the latter science by an Arabic name, **it is a gift we owe to India**."

(source: **Indian Culture and the Modern Age - By Dewan Bahadur K. S. Ramaswami Sastri** Annamalai University. 1956 p.66-67).

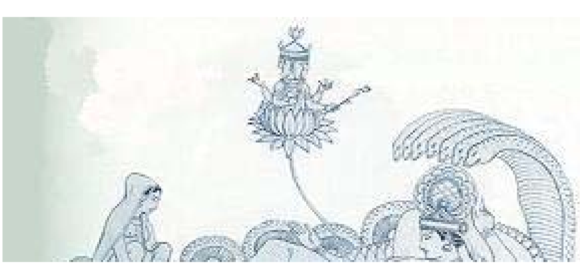
The linkage of God with the infinite is found in the **Bhagavad Gita**, by tradition spoken by Lord Krishna himself, we read:

"O Lord of the universe, I see You everywhere with infinite form…Neither do I see the beginning nor the middle nor the end of Your Universal Form."

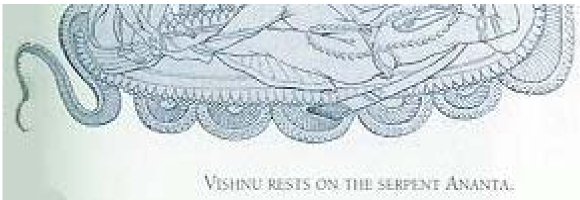
(source: **Infinity: The Quest to Think the Unthinkable - By Brian Clegg** p. 54).

Zero to Infinity in Indian Mysticism

Ananta is Sanskrit for infinity. It is equated with the Supreme Brahman — infinitely powerful and so infinitely free. It is bigger than any quantity that can be imagined; it is bigger than any finite number. Infinity is one of the fundamental axioms upon which contemporary mathematics is based. Sanskrit grammar and interpretation in ancient India were closely linked to the handling of high value numbers. Studies relating to poetry and metrics initiated sastragnaas or scientists to both arithmetic and grammar. Grammarians were just as competent at calculations as professional mathematicians. Indian sastragnaas or scientists, philosophers, astronomers and cosmographers — in order to develop their arithmetical, metaphysical and cosmological speculations concerning ever higher numbers — became at once mathematicians, grammarians and poets. They gave their spoken counting system a truly mathematical structure which had the potential to lead directly to the discovery of the decimal place-value system.



In Indian mysticism, the concept of infinity and zero are very closely linked. In the **Isavasya Upanishad,** there's a line: "Poornasya poornam aadaya poornameva visish-yate". To mathematically explain this, we have to assume that the first poornam represents infinity and the second, zero. **In Sanskrit, poornam means both full and zero. Indian mathematicians knew perfectly well how to distinguish between these two notions which**



are mutually contradictory and which are the inverse of each other. They knew that division by zero gave them infinity. The concept of infinity has always remained an enigma. The Taittiriya Upanishad says: yatho vacho nivartante, apraapya manasa saha — where mind and speech return (being) unable to comprehend. In Indian cosmology, Ananta refers to the Adisesha or the great serpent on which Lord Vishnu reclines, taking His yoga nidra or anantasayanam.

The symbol for infinity is called the leminiscate. English mathematician John Wallis introduced this symbol for the first time in 1655. Hindu mythological iconography contains a similar symbol representing the same idea. The symbol is that of Ananta, the great Adisesha of infinity and eternity, which is always represented, coiled up in a horizontal figure of 8 just like the leminiscate.

Negative numbers had been rejected as solutions of problems in early times. They were eventually admitted in Hindu practical mathematics through problems involving money transactions, since the idea of receiving and owing money was a simple and obvious one — a negative number could be interpreted as a debt. Objection to negative numbers continued up to the early 19th century. Negative numbers are the mirror image of positive numbers. The invention of Cartesian geometry brought the X, Y co-ordinates and numbers came to be represented on a graph. Today, the series of negative natural numbers go up to infinity.

(source: **Zero to Infinity in Indian Mysticism - By T R Rajagopalan** - Times of India).

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju

In his speech introducing the Indian Budget March 1st, 1926, **Sir Basil Blackett** said:

"India long ago revolutionized mathematics, and provided the West with the key to the most far reaching of all the mechanical instrument on which its control of nature has been built, when it presented to Europe through the medium of Arabia the device of the cypher (and the decimal notation) upon which all modern system of numeration depend. even so, India today or tomorrow, will, I am confident, revolutionize western doctrines of progress by demonstrating the insufficiency and lack of finality of much of the West's present system of human values."

(source: **India in Bondage: Her Right to Freedom - Rev. Jabez T. Sunderland** p.356-357).

Georges Ifrah (?) French historian of Mathematics and author of the book, **The Universal History of Numbers** has written:

"The Indian mind has always had for calculations and the handling of numbers an extraordinary inclination, ease and power, such as no other civilization in history ever possessed to the same degree. So much so that Indian culture regarded the science of numbers as the noblest of its arts...A thousand years ahead of Europeans, Indian savants knew that the zero and infinity were mutually inverse notions."

(source: **Histoire Universelle des Chiffres - By Georges Ifrah** Paris - Robert Laffont, 1994, volume 2. p. 3).

“The real inventors of [the numeral system], which is no less important than such feats as the mastery of fire, the development of agriculture, or the invention of the wheel, writing or the steam engine, were the **mathematicians and astronomers of Indian civilization:** scholars who, unlike the Greeks, were concerned with practical applications and who were motivated by a kind of passion for both numbers and numerical calculations.”



Claiming India to be the true birthplace of our numerals, Ifrah salutes the Indian researchers saying that the "...real inventors of this fundamental discovery, which is no less important than such feats as the mastery of fire, the development of agriculture, or the invention of the wheel, writing or the



steam engine, were the mathematicians and astronomers of the Indian civilization: scholars who, unlike the Greeks, were concerned with practical applications and who were motivated by a kind of passion for both numbers and numerical calculations."

He refers to 24 evidences from scriptures from India, whose dates range from 1150 BC until 458 BC. Of particular interest is the work by Indian mathematician **Bhaskaracharya** known as Bhaskara (1150 BC) where he makes a reference to zero and the place-value system were invented by the god **Brahma**. In other words, these notions were so well established in Indian thought and tradition that at this time they were considered to have always been used by humans, and thus to have constituted a **"revelation" of the divinities.**

"It was only after the eighth century BC, and doubtless due to the influence of the Indian Buddhist missionaries, that Chinese mathematicians introduced the use of zero in the form of a little circle or dot (signs that originated in India),...".

The early passion which Indian civilization had for high numbers was a significant factor contributing to the discovery of the place-value system, and not only offered the Indians the incentive to go beyond the "calculable" physical world, but also led to an understanding (much earlier than in our civilization) of the notion of mathematical infinity itself.

Sanskrit notation had an excellent conceptual quality. It was easy to use and moreover it facilitated the conception of the highest imaginable numbers. This is why it was so well suited to the most exuberant numerical or arithmetical-cosmogonic speculations of Indian culture."

"The Indian people were the only civilization to take the decisive step towards the perfection of numerical notation. We owe the discovery of modern numeration and the elaboration of the very foundations of written calculations to India alone."

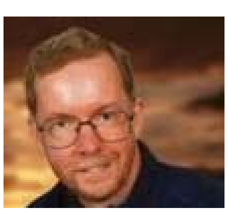
"**It is clear how much we owe to this brilliant civilization, and not only in the field of arithmetic; by opening the way to the generalization of the concept of the number, the Indian scholars enabled the rapid development of mathematics and exact sciences. The discoveries of these men doubtless required much time and imagination, and above all a great ability for abstract thinking. These major discoveries took place within an environment which was at once mystical, philosophical, religious, cosmological, mythological and metaphysical."**

"In India, an aptitude for the study of numbers and arithmetical research was often combined with a surprising tendency towards **metaphysical abstractions;** in fact, the latter is so deeply ingrained in Indian thought and tradition that one meets it in all fields of study, from the most advanced mathematical ideas to disciplines completely unrelated to 'exact sciences.

In short, Indian science was born out of a mystical and religious culture and the etymology of the Sanskrit words used to describe numbers and the science of numbers bears witness to this fact. "

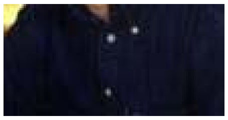
"Sanskrit means "complete", "perfect" and "definitive". In fact, this language is **extremely elaborate**, almost artificial, and is capable of describing **multiple levels of meditation, states of consciousness and psychic, spiritual and even intellectual processes.** As for vocabulary, its richness is considerable and highly diversified. Sanskrit has for centuries lent itself admirably to the diverse rules of prosody and versification. Thus we can see why poetry has played such a preponderant role in all of Indian culture and Sanskrit literature. "

(source: **The Universal History of Numbers - By Georges Ifrah** p 365 - 441).



Brian Clegg (?) author of popular science books has written:

"The characters we use for the numbers arrived here from India via the Arabic world. The Brahmi numerals that have been found in caves and on coins around Mumbai from around the first century AD use horizontal lines for 1 to 3. The squiggles used for 4 to 9, however, are clear ancestors of the numbers we use



today. These symbols were gradually taken up by Arabs and came to Western attention in the 13th century thanks to two books, on written by a traveler from Pisa, the other by a philosopher in Baghdad. The earlier book was written by the philosopher al-Khwarizmi in the 9th century. The Latin translation Algoritmi de numero Indorum (**al-Khwarizmi on the numbers of the Hindus**).

The translation of De numero Indorum slightly predates the man who is credited with introducing the system to the West. Leonardo of Pisa, or by his nickname Fibonacci. In the comments in his book Liberabaci, written in 1202, he states that **he was "introduced to the art of Indian's nine symbols" and it was this book that really brought the Hindu system to the West.**

(source: **Infinity: The Quest to Think the Unthinkable - By Brian Clegg** p. 54 - 60).

Carl B. Boyer (1906 – 1976) in his "**History of Mathematics**" pages 227-228". "...Mohammed ibn-Musa al-Khwarizmi, ..., who died sometime before 850, wrote more than a half dozen astronomical and mathematical works, of which the earliest were probably based on the **Sindhind derived from India.** Besides ... [he] wrote two books on arithmetic and algebra which played very important roles in the history of mathematics. ... **In this work, based presumably on an Arabic translation of Brahmagupta, al-Khwarizmi gave so full an account of the Hindu numerals that he probably is responsible for the widespread but false impression that our system of numeration is Arabic in origin. ...**

Edward Sachau, In a translation of **Alberuni 's "Indica"**, a seminal work of this period (c.1030 AD), writes this in his introduction, **"Many Arab authors took up the subjects communicated to them by the Hindus and worked them out in original compositions , commentaries and extracts. A favourite subject of theirs was Indian mathematics..." etc.**

" Al-Khwarizmi wrote numerous books that played important roles in arithematic and algebra. In his work, De numero indorum (**Concerning the Hindu Art of Reckoning**), it was based presumably on an Arabic translation of **Brahmagupta** where he gave a full account of the Hindu numerals which was the first to expound the system with its digits 0,1,2,3,....,9 and decimal place value which was a fairly recent arrival from India. Because of this book with the Latin translations made a false inquiry that our system of numeration is arabic in origin. The new notation came to be known as that of al-Khwarizmi, or more carelessly, algorismi; ultimately the scheme of numeration making use of the Hindu numerals came to be called simply algorism or algorithm, a word that, originally derived from the name al-Khwarizmi, now means, more generally, any peculiar rule of procedure or operation.

Interestingly, as the article notes, **"The Hindu numerals like much new mathematics were not welcomed by all. In 1299 there was a law in the commercial center of Florence forbidding their use; to this day this law is respected when we write the amount on a check in longhand ."**

"**It is now universally accepted that our decimal numbers derive from forms, which were invented in India and transmitted via Arab culture to Europe,** undergoing a number of changes on the way. We also know that several different ways of writing numbers evolved in India before it became possible for existing decimal numerals to be marred with the place-value principle of the Babylonians to give birth to the system which eventually became the one which we use today. Because of lack of authentic records, very little is known of the development of ancient Hindu mathematics. The earliest history is preserved in the 5000-year-old ruins of a city at Mohenjo Daro, located Northeast of present-day Karachi in Pakistan. **Evidence of wide streets, brick dwellings an apartment houses with tiled bathrooms, covered city drains, and community swimming pools indicates a civilisation as advanced as that found anywhere else in the ancient Orient.**

These early peoples had systems of writing, counting, weighing, and measuring, and they dug canals for irrigation. All this required basic mathematics and engineering. "The special interest of the Indian system is that it is the earliest form of the one, which we use today. Two and three were represented by repetitions of the horizontal stroke for one. **There were distinct symbols for four to nine and also for ten and multiples of ten up to ninety, and for hundred and thousand**."

"…Knowledge of the Hindu system spread through the Arab world, reaching the Arabs of the West in Spain before the end of the tenth century. The earliest European manuscript, which came from the Hindu numerals were modified in north-Spain from the year 976." And finally an important point for those who maintain that the concept of zero was also evident in some other civilisations: **"Only the Hindus within the context of Indo-European civilisations have consistently used zero."**

(source: **Hindu contribution to Mathematics - By B Shantanu** - indiacause.com).

Gopala and Hemachandra and rhythmic patterns



Donald Knuth (1938 -) of Stanford University in **The Art of Computer Programming** also wrote about this:

"Before Fibonacci wrote his work, the sequence Fn had already been discussed by Indian scholars, who had long been interested in rhythmic patterns that are formed from one-beat and two-beat notes. The number of such rhythms having n beats altogether is Fn+1; therefore both **Gopala** (before 1135) and **Hemachandra** (c. 1150) mentioned the numbers 1, 2, 3, 5, 8, 13, 21, ... explicitly."

The system that **Fibonacci** introduced into Europe came from India and used the symbols 1, 2, 3, 4, 5, 6, 7, 8, 9 with, most importantly, a symbol for zero 0.

(source: **Who was Fibonacci?** and **Origins of Fibonacci number** and **Fibonacci numbers or Hemecandra numbers?** and **Gopala** and **Hemachandra numbers everywhere - sepiamutiny.com Hemachandra**).

Ian G. Pearce (?) has written: “Mathematics has long been considered an invention of European scholars, as a result of which the contributions of non-European countries have been severely neglected in histories of mathematics. **Worse still, many key mathematical developments have been wrongly attributed to scholars of European origin. This has led to so-called Eurocentrism.** ...The purpose of my project is to highlight the major mathematical contributions of Indian scholars and further to emphasize where neglect has occurred and hence elucidate why the **Eurocentric ideal is an injustice and in some cases complete fabrication.”**



“It is through the works of Vedic religion that we gain the first literary evidence of Indian culture and hence mathematics. Written in Vedic Sanskrit the Vedic works, Vedas and Vedangas (and later Sulbasutras) are primarily religious in content, but embody a large amount of astronomical knowledge and hence a significant knowledge of mathematics. ... 'The need to determine the correct times for Vedic ceremonies and the accurate construction of altars led to the development of astronomy and geometry.'”

“I feel it important not to be controversial or sweeping, but it is likely European scholars are resistant due to the way in which the inclusion of non-European, including Indian, contributions **shakes up views that have been held for hundreds of years, and challenges the very foundations of the Eurocentric ideology. ...** It is almost more in the realms of psychology and culture that we argue about the effect the discoveries of non-European science may have had on the 'psyche' of European scholars. ... **To summarize, the main reasons for the neglect of Indian mathematics seem to be religious, cultural and psychological”**

(source: **Indian Mathematics: Redressing the balance' - 'Abstract' - By Ian G. Pearce** – '(IGP-IM:RB) '**Mathematics in the service of religion: I. Vedas and Vedangas' and Conclusion.**

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju

Remarking on this valuable contribution specially the discovery of number from one to nine and zero, which is considered to be the greatest and the most important, next only to the introduction of letters, **Prof. Halsted of USA holds that no discovery in Arithmetic has contributed so much in the development of human intelligence and power. The Hindus can claim to be superior to the Greeks for the introduction of this system.**

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co.

1962 p. 121).

Zero is the embodiment of purna (full), lopa (absence), akasa (universe), bindu (dot), **sunya** (circle), in Indian literary and cultural traditions. The concept got concretized in the form of a symbol like dot or circle to fill up the empty space created in Indian decimal place-value concept. **The scientific advances of the West would have been impossible had scientists continued to depend upon the Roman numerals and been deprived of the simplicity and flexibility of the decimal system and its main glory, the zero.**

A 10th century traveler Masaudi, in his Arabic work Meadows of Gold, records that a Hindu Raja called Pandit who counted nine digits by memory. Abu Zafar Muhammad Al Khwarizm also mentions Hindu mathematicians, as does Al Beruni. In the Journal of the Bengal Asiatic Society (1907 p. 475), Feroz Abadi is quoted to have given the history of 'Hindsa' (= 0).

The number '10' is a special contribution of Hindu arithmetic. So the zero was called 'Hindsa' in Persian.

(source: **Hinduism: Its Contribution to Science and Civilization - By Prabhakar Balvant Machwe** p. 10-14).

Muhammad ibn Musa al-Khawarazmi 772-773 A.D. who journeyed east to India to learn the sciences of that time. He introduced Hindu numerals, including the concept of zero, into the Arab world. Abu Abdulla Muhammad Ibrahim-al-Fazari translated **Sidhanta** from Sanskrit into Arabic, which, according to **George Sarton** (1884-1956) the great Harvard historian of science, wrote in his monumental **Introduction to the History of Science,** provided "possibly the vehicle by means of which the Hindu numerals were transmitted from India to Islam".

***

Algebra

Brahmagupta gives the following rules concerning operations carried out on what he calls "fortunes" (dhana), "debts" (rina) and "nothing" (kha).

A debt minus zero is a debt.
A fortune minus zero is a fortune.
Zero (shunya) minus zero is nothing. (kha).
A debt subtracted from zero is a fortune.
So a fortune subtracted from zero is a debt.
The product of zero multiplied by a debt or fortune is zero.
The product of zero multiplied by itself is nothing.
The product or the quotient of two fortunes is one fortune.
The product or the quotient of two debts is one debt.
The product or the quotient of a debt multiplied by a fortune is a debt.
The product or the quotient of a fortune multiplied by a debt is a debt.

Modern algebra was born, and the mathematician had thus formulated the basic rules: by replacing "fortune" and "debt" respectively with "positive number" and "negative number", we can see that at that time the Indian mathematicians knew the famous "rule of signs" as well as all the fundamental rules of algebra.

(source: **The Universal History of Numbers - By Georges Ifrah** p 439).



Florian Cajori (1859 - 1930) Swiss-born U.S. educator and mathematician whose works on the history of mathematics says:

"Indians were the "real inventors of Algebra"

(source: **Is India Civilized - Essays on Indian Culture - By Sir John Woodroffe** Ganesh & Co. Publishers 1922 p. 182).

Friedrich Rosen (1805-1837) edited and translated in 1831, *The Algebra of Mohammed ben Musa*. This is the oldest Arabic on mathematics and **it shows that**

the Arabs borrowed algebra from India.

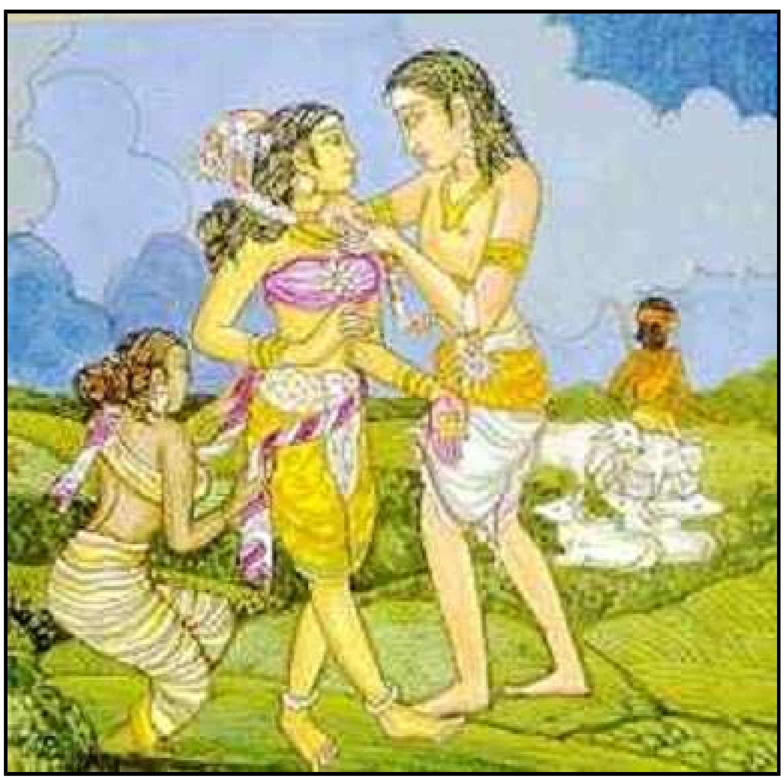
(source: **German Indologists: Biographies of Scholars in Indian Studies writing in German** - **By Valentine Stache-Rosen** p.24-25).

Algebra went to Western Europe from the Arabs - i.e. (Al-jabr, adjustment) who adopted it from India rather than from Greece. Sir Monier-Williams, T. S. Colebrooke, and Macdonell hold that the Arabs got Algebra from the Hindus. The great Indian leaders in this field, as in astronomy were **Aryabhata, Brahmagupta, and Bhaskara.** The last appears to have invented the radical sign and many algebraic symbols. These men created the conception of a negative quantity, without which algebra would have been impossible; they found the square root of 2, and solved, in the eighth century A.D., indeterminate equations of the second degree that were **unknown to Europe until the days of Euler a thousand years later. They expressed their science in poetic form and gave to mathematical problems a grace characteristic to India's Golden Age.**

Henry Thomas Colebrooke (1765-1837) wrote: "They (the Hindus) understood well the arithmetic of surd roots; they were aware of the infinite quotient resulting from the division of finite quantities by cipher; they knew the general resolution of equations of the second degree, and had touched upon those of higher denomination, resolving them in the simplest cases, and in those in which the solution happens to be practicable by the method which serves for quadratics; they had attained a general solution of indeterminate problems of the first degree; they had arrived at a method for deriving a multitude of solutions or answers to problems of the second degree from a single answer found tentatively."

"And this, says Colebrooke in conclusion, was as near an approach to a general solution of such problems as was made until the days of La Grange."

(source: **Miscellaneous Essays - By H. T. Colebrooke** Volume II p. 416 - 418).



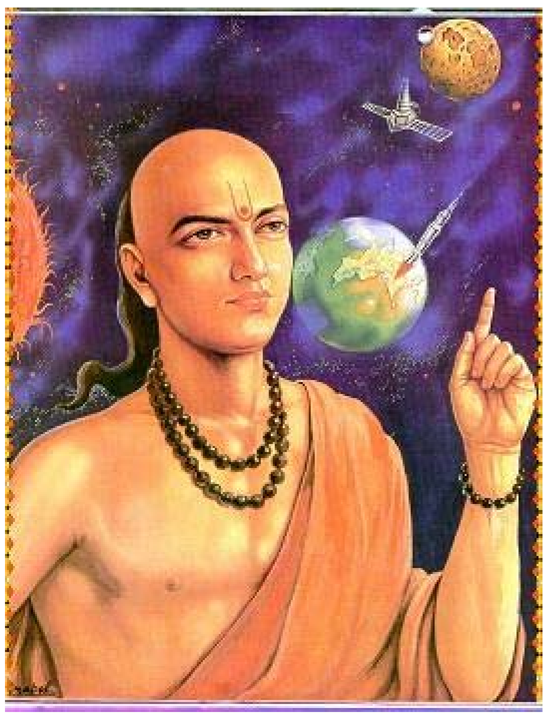
" Out of a swarm of bees one-fifth part settled on a Kadamba blossom; one-third on a Silindhra flower; three times the difference of those numbers flew to the bloom of a Kutaja. One bee, which remained, hovered about in the air. Tell me, charming woman, the number of bees ...Eight rubies, ten emeralds, and a hundred pearls, which are in thy ear-ring, my beloved, were purchased by me for thee at an equal

amount; and the sum of the prices of the three sorts of gem was three less than half a hundred; tell me the price of each, auspicious woman."

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"The Indian mind has always had for calculations and the handling of numbers an extraordinary inclination, ease and power, such as no other civilization in history ever possessed to the same degree. So much so that Indian culture regarded the science of numbers as the noblest of its arts."

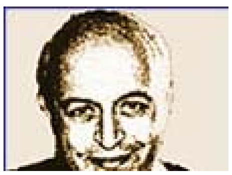
Aryabhata (475 A.D. - 550 A.D.) is the first well known Indian mathematician. Born in Kerala, he completed his studies at the university of Nalanda. In the section **Ganita** (calculations) of his astronomical treatise **Aryabhatiya** (499 A.D.) he made the fundamental advance in finding the lengths of chords of circles, by using the half chord rather than the full chord method used by Greeks. He gave the value of pi as 3.1416, claiming, for the first time, that it was an approximation. (He gave it in the form that the approximate circumference of a circle of diameter 20000 is 62832.) He also gave methods for extracting square roots, summing arithmetic series, solving indeterminate equations of the type $ax - by = c$, and also gave what later came to be known as the table of Sines. He also wrote a text book for astronomical calculations, **Aryabhatasiddhanta**. Even today, this data is used in preparing Hindu calendars (**Panchangs**). In recognition to his contributions to astronomy and mathematics, India's first satellite was named Aryabhata.



Aryabhatta (475 A.D. - 550 A.D).

Aryabhatta put forward a brilliant thesis with regard to the Earth's rotation on its axis.

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Soviet historians, **K. Antonova, G. Bongard-Levin, and G. Kotovsky**, authors of **A History of India**, Moscow, Volume I and II 1973, have spoken highly of scientists of ancient India and their high originality:

"In the ancient period and in the early Middle Ages lived the outstanding



mathematicians **Aryabhatta** (5-6th centuries), **Varahamihira** (6th century) and **Brahmagupta** (late 6th and early 7th centuries), whose discoveries anticipated many scientific achievements of modern times. Aryabhata knew that pi equaled 3.1416. The theorem known to us as Pythagoras' theorem was also known at that time. Aryabhata proposed an original solution in whole numbers to the linear equations with two unknowns that closely resembles modern solutions.

"The ancient Indians evolved a system for calculation using zero, which was later taken over by the Arabs (the so-called Arabic numerals) and alter from them by other peoples. The Aryabhatta school was also familiar with sine and cosine.

"Scholars of the Gupta period were already acquainted with the movement of the heavenly bodies, the reasons for eclipses of the Sun and the Moon. Aryabhatta put forward a brilliant thesis with regard to the Earth's rotation on its axis."

"Aryabhatta's follower, Brahmagupta, put forward solutions for a whole series of equations."

"Indian scholars of this period also scored important successes in the sphere of astronomy. Certain astronomical treatises of this period have been preserved, and these siddhantas bear witness to the high level of astronomical knowledge attained by the ancient Indians."

"Brahmagupta (many centuries before Newton) suggested that objects fall to the ground as a result of terrestrial gravity."

"Interesting material relating to astronomy, geography and mineralogy is found in Varahamihira's work Brihat-samhita...."

(source: **A History of India - By K. Antonova, G. Bongard-Levin, and G. Kotovsky** Moscow, Volume I and II 1973 p. 169-171).

Aryabhatta was a great astronomer of remarkable originality. He is famous for his suggestions of the diurnal revolution of the earth on its own axis. Another important conclusion was about the apparent motion of the sun and the moon. He observes: **"The starry vault is fixed: it is the earth which, moving on its own axis, seems to cause the rising and the setting of the planets and stars."**

(source: **Main Currents in Indian Culture - By S. Natarajan** - The Institute of Indo-Middle East Cultural Studies. 1960. p 62-63).

Yavadvipa, the ancient name for Java, to which Sugriva sent search parties looking for Sita, is a Sanskrit name mentioned in the Ramayana. Aryabhatta wrote that when the sun rose in Sri Lanka, it was midday in Yavakoti (Java) and midnight in the Roman land. In the Surya Siddanata reference is also made to the Nagari Yavakoti with golden walls and gates.

(source: **India and World Civilization - By D. P. Singhal** Pan Macmillan Limited. 1993. p. 323).

Mnemonic and shorthand code letters were used by the Hindu astronomer **Aryabhat**, who composed his Aryabhatiya in 499 A.D. He answers the question: “How many times does the Earth rotate in a Mahayuga?” by the sutra – Ngishi Bunlrukshshru. Its letters count up to 15,82,23,75,200.

The second **Aryabhatta (II)** has also given such cryptic numberal-alphabets:

Kanadhajhajhujhila = 1599993
Mudayasinadha = 58179

(source: **Hinduism: Its Contribution to Science and Civilization - By Prabhakar Balvant Machwe** p. 10-14).

Comparing the Hindus and the Greeks as regards their knowledge of algebra, **Sir Mountstuart Elphinstone** says:

"There is no question of the superiority of the Hindus over their rivals in the perfection to which they

brought the science. **Not only is Aryabhatta superior to Diaphantus** (as is shown by his knowledge of the resolution of equations involving several unknown quantities, and in general method of resolving all indeterminate problems of at least the first degree), but he and his successors press hard upon the discoveries of algebraists who lived almost in our own time!"

(source: **History of India - By Mountstuart Elphinstone** London: John Murray Date of Publication: 1849 p. 131).



The **Aryabhatiya** was translated into Latin in the 13th century. Through this translation European mathematicians eventually learned methods for calculating the squares of triangles and the volumes of spheres, as well as square and cube roots. **He had conceptualized the ideas about the cause of eclipses and the sun being the source of moonlight a thousand years before the Europeans.** A revolutionary thinker in many areas, Aryabhata gave the radius of the planetary orbits in terms of the radius of the earth-sun orbit – that is, their orbits as basically their periods of rotation around the sun. He explained that the glow of the moon and planets was the result of reflected sunlight. **And with incredible astuteness, he conceptualized the orbits of the planets as ellipses, a thousand years before Kepler reluctantly (he originally preferred circles) came to the same conclusion.** His value for the length of the year at 365 days, six hours, twelve minutes, and thirty seconds, however, is a slightly overestimate; the true value is fewer than 365 days and 6 hours.

"Brahmagupta became the head of the astronomical observatory at Ujjain, the foremost mathematical center of ancient India, where great mathematicians such as **Varahamihira** had worked and built a strong school of mathematical astronomy. The **Brahmasphutasidhanta** contains 25 chapters, the first ten of which are arranged by topics such as true longitudes of the planets, lunar eclipses, solar eclipses, rising and settings, the moon's crescent, the moon's shadow, conjunctions of the planets with the fixed stars. A large part of the Brahmasphutsidhanta was translated into Arabic in the early 770s and became the basis of various studies by the astronomer Ya'qub ibn Tariq. In 1126 it was translated into Latin. This translation, along with other associated texts translated from Arabic, provided the basis for the Indo-Arabic stage of Western astronomy. The culmination of southern Indian astronomy was the tradition begun by Madhava in Kerala right before 1400. **Madhava** was renowned for his derivation of the infinite series for pi and the power series for trigonometric functions. His pupil **Paramesvara** attempted to correct the lunar parameters by conducting a long series of eclipse observations between 1393 and 1432. In these observations he used an astrolabe, an instrument devised to measure the positions of heavenly bodies, to determine the angle of altitude of the eclipsed body and possibly, the time of the phase of the eclipses."

(source: **Lost Discoveries: The Ancient Roots of Modern Science - By Dick Teresi** p. 133 - 136).

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju

In the **Jewish Encyclopedia** Vol. XII p 689, it is noted,

"Aryabhatta, the noted Hindu astronomer who lived about 476 A.D. and who is called the Newton of the country, wrote many works on Algebra and Geometry. He first discovered the rotation of the earth round its own axis. As a Jewish writer says the theory that earth is a sphere revolving round its own axis which immortalized Copernicus, was previously known to the Hindus, who were instructed in the truth of it by Aryabhatta."

Jogesh Chandar Roy (1859-1965) Eminent scholar, educationist, writer, linguist, historian. Owing to his talent was conferred many accolades like D.Litt., Acharya, Bidyanidhi, Roy Bahadur etc. He held that the Vedic sages first admitted that the world is round ohterwise the advent of dawn (Usha) in the hymns, before sunrise becomes meaningless."

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co.

1962 p. 126).



Brahmagupta (598 A.D. - 665 A.D.) is renowned for introduction of negative numbers and operations on zero into arithmetic. His main work was *Brahmasphutasiddhanta*, which was a corrected version of old astronomical treatise *Brahmasiddhanta*. This work was later translated into Arabic as **Sind Hind.** He formulated the rule of three and proposed rules for the solution of quadratic and simultaneous equations. He was the first mathematician to treat algebra and arithmetic as two different branches of mathematics. He gave the solution of the indeterminate equation $Nx^2+1 = y^2$. He is also the founder of the branch of higher mathematics known as "Numerical Analysis".

The Hindus were aware of the length of diameter and circumference of the earth. According to Brahmagupta and Bhaskarachary the diameter is 7182 miles, some calculate it to be 7905 miles, modern scientists take it to be 7918 miles. For the sake of astronomical experiments the Hindus introduced Sanka Yantra and Ghati Yantra, the apparatus for measurement.

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co. 1962 p. 126).

After Brahmagupta, the mathematician of some consequence was **Sridhara**, who wrote *Patiganita Sara*, a book on algebra, in 750 A.D. Even Bhaskara refers to his works. After Sridhara, the most celebrated mathematician was **Mahaviracharaya** or Mahavira**.** He wrote *Ganita Sara Sangraha* in 850 A.D., which is the first text book on arithmetic in present day form. He is the only Indian mathematician who has briefly referred to the ellipse (which he called *Ayatvrit*). The Greeks, by contrast, had studied conic sections in great detail.

Bhaskara (1114 A.D. - 1185 A.D.) or **Bhaskaracharaya** is the most well known ancient Indian mathematician. He was born in 1114 A.D. at Bijjada Bida (Bijapur, Karnataka) in the Sahyadari Hills. He was the first to declare that any number divided by zero is infinity and that the sum of any number and infinity is also infinity. He is famous for his book *Siddhanta Siromani* (1150 A.D.). It is divided into four sections - **Leelavati** (a book on arithmetic), *Bijaganita* (algebra), *Goladhayaya* (chapter on sphere - celestial globe), and **Grahaganita** (mathematics of the planets). *Leelavati* contains many interesting problems and was a very popular text book. Bhaskara introduced *chakrawal*, or the cyclic method, to solve algebraic equations. **Six centuries later, European mathematicians like Galois, Euler and Lagrange rediscovered this method and called it "inverse cyclic".** Bhaskara can also be called the founder of differential calculus. He gave an example of what is now called "differential coefficient" and the basic idea of what is now called "Rolle's theorem". Unfortunately, later Indian mathematicians did not take any notice of this. Five centuries later, Newton and Leibniz developed this subject. As an astronomer, Bhaskara is renowned for his concept of *Tatkalikagati* (instantaneous motion).

(source: **Ancient Indian Mathematicians** and http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Bhaskara_II.html).

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju



"A Persian translation of the Veeju-Ganitu was made in India," says Mr. Edward Strachey, "in the year 1634, by Ata Oollah Rusidee." The same gentlemen says, "Foizee, in 1587, translated the Leelavatee, a work on arithmetic, mensuration," etc. from which work it appears that "**Bhaskara** must have written about the end of the 12th century.."

"We must not," adds **Edward Strachey** author of **Bija ganita; or, The algebra of the Hindus**, "be too fastidious in our belief, because we have not found the works of the teachers of Pythagoras; we have access to the wreck only of their ancient learning; but when such traces of a more perfect state of knowledge; we see that the Hindoo algebra 600 years ago, had, in the most interesting parts, some of the most curious modern European discoveries, and when we see, that it was at that time applied to astronomy, we cannot reasonably doubt the originality and the antiquity of mathematical learning among the Hindoos."

(source: **A View of the History, Literature, and Mythology of the Hindoos - By William Ward** (1769-1823) volume II p 329 London 1822).

Sir Mountstuart Elphinstone wrote: "In the Surya Siddhanta is contained a system of trigonometry which not only goes beyond anything known to the Greeks, but involves theorem which were not discovered in Europe till two centuries ago."

(source: **Sanskrit Civilization - By G. R. Josyer** p. 2).

The discovery of the law of gravitation which immortalized Newton was known in India by **Bhaskaracharya** long before the birth of Newton. In support of the assumption of this view there is sufficient evidence in a verse in **Sidhanta Siromany** by its author. Bhaskaracharya holds that when the earth which is endowed with the power of attraction drags with her own power heavy objects on the sky it appears that objects are falling but actually they are not falling, they are only being dragged by the power of attraction of the earth. When everything on the sky drags each other equally where will the earth fall: It is explained that earth, planets, stars, moon, sun etc - each of them is being dragged by the other with its respective power of attraction and as a result of this attraction none of them is removed from its axis.

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co. 1962 p. 127).

Sir William Wilson Hunter wrote: "The Hindus attained a very high proficiency in arithmetic and algebra independently of any foreign influence." The romance of the composition of **Lilavati** - the standard Hindu text book on Arithmetic by Bhaskaracharya - is very interesting and charming. It deals not only with the basic elements of the science of arithmetic but also with questions of interest, of barter, of permutations and combinations, and of mensuration. Bhaskaracharya knew the law of gravitation. The **Surya Siddhanta** is based on a system of trigonometry. Professor Wallace says: "In fact it is founded on a geometrical theorem, which was not known to the geometricians of Europe before the time of Vieta, about two hundred years ago. And it employs the sine of arcs, a thing unknown to the Greeks." The 47th proposition of Book I of Euclid, which is ascribed to Pythagoras was known long ago to the Hindus and must have been learnt from them by Pythagoras.

(source: **Indian Culture and the Modern Age - By Dewan Bahadur K. S. Ramaswami Sastri** Annamalai University. 1956 p. 67).

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Geometry

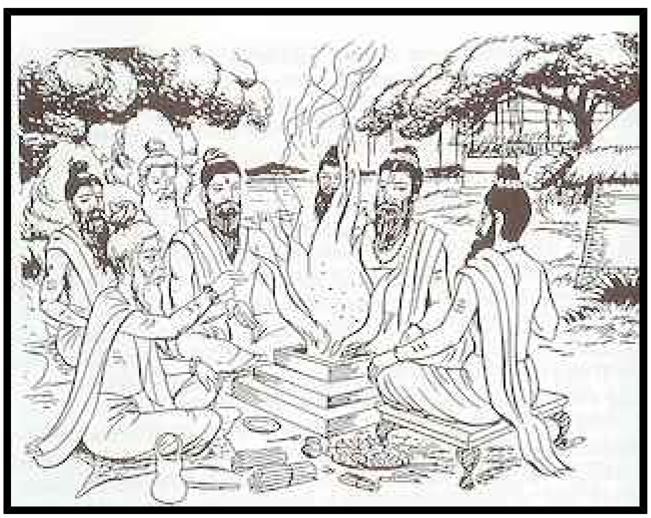
Geometry, like Astronomy, owes its origin in India to religion, and Grammar and Philosophy too were

similarly inspired by religion.

As **George Frederick William Thibaut** (1848-1914) author of **Mathematics in the making in Ancient India**, remarked: "The want of some rule by which to fix the right time for the religious altar gave the first impulse to astronomical observations; urged by this the priest, remained watching night after night the advancement of the moon through the circle of the Nakshatras...The laws of phonetics were investigated....the wrong pronunciation of a single letter of the text; grammar and etymology had the task of securing the right understanding of the holy texts. And Thibaut then lays down the principle, which should never be overlooked by Indian historians, **that whatever science "is closely connected with the Ancient Indian religion, must be considered as having sprung up among the Indians themselves, and not borrowed from other nations."**

Geometry was developed in India from the rules of the construction of the altars. The Black Yajur Veda (V.4.11) enumerates the different shapes in which altars could be constructed and Baudhayana and Apastamba furnish us with full particulars about the shape of these chitis and the bricks which had to be employed for their construction. The Sulva Sutras date from the eighth century before Christ. The geometrical theorem that the square of the hypotenuse is equal to the squares of the other two sides of a rectangular triangle is ascribed by the Greeks to Pythagoras; **but it was known in India at least two centuries before, and Pythagoras undoubtedly learnt this rule from India.**

(source: **Journal of the Asiatic Society of Bengal**, 1875. p. 227 and **A History of Civilization in Ancient India** Based on Sanscrit Literature - **By Romesh Chunder Dutt** p. 240-243)



Vedic altars and sacrificial places were constructed according to strict geometrical principles. The Vedic (altar) had to be stacked in a geometrical form with the sides in fixed proportions, and brick altars had to combine fixed dimensions with a fixed number of bricks. Again, the surface areas were so designed that altars could be increased in size without change of shape, which required considerable geometrical ingenuity.

Geometrical rules found in the **Sulvasutras**, therefore, refers to the construction of squares and rectangles, the relation of the diagonal to the sides, equivalent rectangles and squares, equivalent circles and squares, conversion, of oblongs into squares and vice versa, and the construction of squares equal to the sum or difference of two squares. In such relations a prior knowledge of the Pythagorean theorem, that the square of the hypotenuse of a right-angled triangle is equal to the sum of squares of the other two sides, is disclosed.

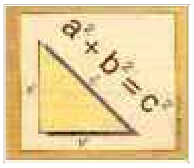
In measurement and construction of altars the priests formulated the Pythagorean theorem (by which the square of the hypotenuse of a right-angled triangle equals the sum of the squares of the other side) several hundred years before the birth of Christ.

As every schoolchild knows, the most important theorem in geometry is that of Pythagoras. Yet, there is no evidence that either the statement or the proof was known by the man to whom it is credited. The earliest statement can be found in the Sulbasutra of Baudhyana. Baudhayana has preserved its germination in religious rituals. The fact that ancient Indians knew this theorem was recognized quite early by some European scholars. Among the first was **G. Thibaut**, a historian of science, who left the impression that in geometry the Pythagoreans were the pupils of the Indians. Scholars unhappy with this idea tried to refute it, thought their refutation was, as **Abraham Seidenberg,** noted, were no more haughty dismissals.

The Formula known today as the Pythagorean Theorem was first postulated by Indian mathematician - **Baudhayana** in the 6th century C. E. long before Europe's math whizzies. In 497 C.E. Aryabhatta calculated the value of "pi" as 3.1416. Algebra, trigonometry and the concepts of algorithm,

square root originated in India. Quadratic equations were propounded by Sridharacharya in the 11th century.

The largest number used by Greeks and Romans were 106, whereas Indians used numbers as big as 10 to the power of 53, as early as 5000 BCE. Even geometry called **Rekha Ganita** in ancient India, was applied to draft mandalas for architectural purposes and for creating temple motifs.



Professor H. G. Rawlinson writes: " It is more likely that Pythagoras was influenced by India than by Egypt. Almost all the theories, religions, philosophical and mathematical taught by the Pythagoreans, were known in India in the sixth century B.C., and the Pythagoreans, like the Jains and the Buddhists, refrained from the destruction of life and eating meat and regarded certain vegetables such as beans as taboo" "It seems that the so-called Pythagorean theorem of the quadrature of the hypotenuse was already known to the Indians in the older Vedic times, and thus before Pythagoras

(source: **Legacy of India** 1937, p. 5).

Romesh Chunder Dutt, the famous Indian historian holds that the world is indebted to the Hindus for Geometry and not to the Greeks.

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co. 1962 p. 124).

Professor Maurice Winternitz is of the same opinion: "As regards Pythagoras, it seems to me very probable that he became acquainted with Indian doctrines in Persia." (Visvabharati Quarterly Feb. 1937, p. 8).

It is also the view of **Sir William Jones** (Works, iii. 236), **Colebrooke** (Miscellaneous Essays, i. 436 ff.). **Schroeder** (**Pythagoras und die Inder**), **Garbe** (**Philosophy of Ancient India**, pp. 39 ff), **Hopkins** (**Religions of India**, p. 559 and 560) and **Macdonell** (**Sanskrit Literature**, p. 422).

(source: **Eastern Religions & Western Thought - By S. Radhakrishnan** ISBN: 0195624564 p. 143).

Ludwig von Schröder German philosopher, author of the book **Pythagoras und die Inder (Pythagoras and the Indians),** published in 1884, he argued that Pythagoras had been influenced by the Samkhya school of thought, the most prominent branch of the Indic philosophy next to Vedanta.

(source: **In Search of The Cradle of Civilization: : New Light on Ancient India - By Georg Feuerstein, Subhash Kak & David Frawley** p. 252).

" Nearly all the philosophical and mathematical doctrines attributed to Pythagoras are derived from India."



Sir William Temple, (1628-1699) English statesman and diplomat, in his **Essay upon the Ancient and Modern Learning** (1690) he wrote:

"From these famous Indians, it seems most probable that Pythagoras learned, and transported into Greece and Italy, the greatest part of his natural and moral philosophy, rather than from the Aegyptians...Nor does it seem unlikely that the Aegyptians themselves might have drawn much of their learning from the Indians..long before..Lycurgus, who likewise traveled to India, brought from thence also the chief principles of his laws."

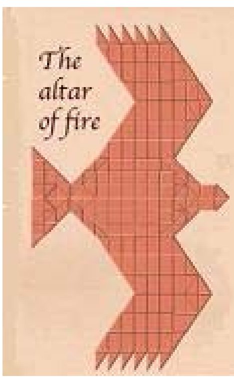
Temple's ideas remained in isolation in his period until they were revived in the middle of the 18th century when a battle raged between the 'believers' and the 'infidels' on the question of the value of Mosaic interpretation of history.

(source: **Much Maligned Monsters: A History of European Reactions to Indian Art - By Partha Mitter** p. 191).

Aryabhata, found the area of a triangle, a trapezium and a circle, and calculated the value of "pi" (the relation of diameter to circumference in a circle) at 3.1416 - a figure not equaled in accuracy until the days of Purbach (1423-61) in Europe. **Bhaskara** anticipated the differential calculus, Aryabhata drew up a table of sines, and the **Surya Siddhanta** provided a system of trigonometry more advance than anything known to the Greeks. He had tabulated the sine function (unknown in Greece) for every $3^{3}/_{4}$º of arc from $3^{3}/_{4}$º to 90º. By 670 the system had reached northern **Mesopotamia**, where the **Nestorian bishop Severus Sebokht** praised its Hindu inventors as discoverers of things more ingenious than those of the Greeks. Muslims began the acquisition of foreign learning, and, by the time of the **Caliph al-Mansur** (d. 775), such Indian and Persian astronomical material as the **Brahma-sphuta-siddhanta** and the Shah's Tables had been translated into Arabic.

A 3,000-year-old ritual was resurrected at Panjal in Kerala in April 1975. A 12-day Agnicayana, or Atiratra, was performed on a bird-shaped altar of a thousand bricks. The altar was a geometricians' delight.

The area of each layer of the altar, for instance, was seven and a half times a square purusa, the size of the sacrificer or the Yajamana. A fifth of the size of the Yajamana, panchami, was the basic unit of the bricks.



The rules for measurement and construction of sacrificial altars are found in the Sulba Sutras, the earliest documents of geometry in India. Sulba means cord. Of the various Sulba Sutras, those of Baudhayana, Apastamba and Katyayana are best known. The mathematical knowledge in the texts comes from the creation of altars or bricks in various shapes-rhombus, isosceles trapezium, square, rectangle, isosceles right-angled triangle or circle. A square-shaped altar sometimes had to become circular without any change in the area or vice-versa. Obviously, the authors of the Sulba texts knew the value of pi, which is the ratio of the circumference to the diameter of a circle.

The theory of right angles is attributed to Greek philosopher Pythagoras (6th century BC). But **Baudhayana** mentions that the diagonal of a rectangle produces by itself both (the areas) produced separately by its two sides. In simple terms, this means that the square of the diagonal is equal to the sum of the squares of two sides. In the next rule he says that the rectangles for which the theorem is true have the sides as 3 and 4 [32+42=52], 12 and 5, 15 and 8, 7 and 24, 12 and 35, 15 and 36. **The theorem is given in all the Sulba Sutras**.

Eminent mathematician A. K. Bag, he says tackling of mathematical and geometrical problems with rational numbers and irrational numbers [such as square-root of 2] was a unique achievement of early Indians. They even had technical terms such as dvikarani, trikarani and panchakarani (for square-roots of 2, 3 and 5) and so on and gave their values to a high degree of approximation.

The mathematics in Sulba texts also involves a highly sophisticated brick technology. Ten types of bricks were used to build the altar at Panjal.

Sir Monier-Williams says: "To the Hindus is due the invention of algebra and geometry, and their application to astronomy."

(source: **Indian Wisdom - By Monier Williams** p. 185).

Count Magnus Fredrik Ferdinand Bjornstjerna author of **Theogony of the Hindus** says: "We find in Ayeen-Akbari, a journal of the Emperor Akbar, that the Hindus of former times assumed the diameter of a circle to be to its periphery as 1,250 to 3,927. The ratio of 1,250 to 3,927 is a very close approximation to the quandrature of a circle, and differs very little form that given by Metius of 113 to 355. In order to obtain the result thus found by the Brahmans, even in the most elementary and simplest way, it is necessary to inscribe in a circle a poligon of 768 sides, an operation, which cannot be performed arithmetically without the knowledge of some peculiar properties of this curved line, and at least an extraction of the square root of the ninth power, each to ten places of decimals. **The Greeks and Arabs have not given anything so approximate."**

Professor Wallace says: "However ancient a book may be in which a system of trigonometry occurs, we may be assured **it was not written in the infancy of the science. Geometry must have been known in India long before the writing of Surya Siddanata."** which is supposed by the Europeans to have been written before 2000 B. C. E.

(source: **Sanskrit Civilization - By G. R. Josyer** p. 2-3).

Influence of Hindu Geometry on Greeks:



In his monumental work, **The origin of mathematics, Archive for History of Exact Sciences**. vol. 18, 301-342, **Abraham Seidenberg** remarks: "By examining the evidence in the **Shatapatha Brahmana,** we now know that Indian geometry predates Greek geometry by centuries. For example, the earth was represented by a circular altar and the heavens were represented by a square altar and the ritual consisted of converting the circle into a square of an identical area. There we see the beginnings of geometry! Two aspects of the 'Pythagoras' theorem are described in the Vedic literature. One aspect is purely algebraic that presents numbers a, b, c for which the sum of the squares of the first two equals the square of the third. The second is the geometric, according to which the sum of the areas of two square areas of different size is equal to another square. The Babylonians knew the algebraic aspect of this theorem as early as 1700 BCE, but they did not seem to know the geometric aspect. The Shatapatha Brahmana, which precedes the age of Pythagoras, knows both aspects. Therefore, the Indians could not have learnt it from the Old-Babylonians or the Greeks, who claim to have rediscovered the result only with Pythagoras. India is thus the cradle of the knowledge of geometry and mathematics."

So, contrary to the European belief that Hindus were influenced by the Greek geometry, the facts prove that it is the other way round. Most of the aspects of planar geometry described by Euclid and other Greek mathematicians were already known to Indians at least 2500 years before the Greeks. In fact, there are proofs which hint towards the fact Greeks were influenced by the ancient Hindu Mathematics and Geometry. **Bibhuti Bhushan Datta** in his book **"Ancient Hindu Geometry"** states:

"...One who was well versed in that science was called in ancient India as samkhyajna (the expert of numbers), parimanajna (the expert in measuring), sama-sutra-niranchaka (Uinform-rope-stretcher), Shulba-vid (the expert in Shulba) and Shulba-pariprcchaka (the inquirer into the Shulba). Of these term, viz, 'sama-sutra-niranchaka' perhaps deserves more particular notice. For we find an almost identical term, 'harpedonaptae' (rope-stretcher) appearing in the writings of the Greek Democritos (c. 440 BC). It seems to be an instance of Hindu influence on Greek geometry. For the idea in that Greek term is neither of the Greeks nor of their acknowledged teachers in the science of geometry, the Egyptians, but it is characteristically of Hindu origin." The English word 'Geometry' has a Greek root which itself is derived from the Sanskrit word 'Jyamiti'. In Sanskrit 'Jya' means an arc or curve and 'Miti' means correct perception or measurement.

The Sulba Sutras, however, date from about the eighth century B.C. E. and **Dr. Thibault** has shown that the geometrical theorem of the 47th proposition, Book I, which tradition ascribes to Pythagoras, was solved by the Hindus at least two centuries earlier, thus confirming the conclusion of **Von Schroeder** that the Greek philosopher owed his inspiration to India.

(source: **History of Hindu Chemistry**, Volume I p. XXIV).

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A. L. Basham, foremost authority on ancient India, writes in **The Wonder That Was India**:

"Medieval Indian mathematicians, such as Brahmagupta (seventh century), Mahavira (ninth century), and Bhaskara (twelfth century), made several discoveries which in Europe were not known until the Renaissance or later. They understood the import of positive and negative quantities, evolved sound systems of extracting square and



cube roots, and could solve quadratic and certain types of indeterminate equations." Mahavira's most noteworthy contribution is his treatment of fractions for the first time and his rule for dividing one fraction by another, which did not appear in Europe until the 16th century.

B. B. Dutta writes: "The use of symbols-letters of the alphabet to denote unknowns, and equations are the foundations of the science of algebra. The Hindus were the first to make systematic use of the letters of the alphabet to denote unknowns. They were also the first to classify and make a detailed study of equations. Thus they may be said to have given birth to the modern science of algebra."

The great Indian mathematician Bhaskaracharya (1150 C.E.) produced extensive treatises on both plane and spherical trigonometry and algebra, and his works contain remarkable solutions of problems which were not discovered in Europe until the seventeenth and eighteenth centuries. **He preceded Newton by over 500 years in the discovery of the principles of differential calculus.**

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju

A. L. Basham writes further, "The mathematical implications of zero (sunya) and infinity, never more than vaguely realized by classical authorities, were fully understood in medieval India. Earlier mathematicians had taught that X/0 = X, but Bhaskara proved the contrary. He also established mathematically what had been recognized in Indian theology at least a millennium earlier: that infinity, however divided, remains infinite, represented by the equation /X = ."

In the 14th century, **Madhava,** isolated in South India, developed a power series for the arc tangent function, apparently without the use of calculus, allowing the calculation of to any number of decimal places (since arc tan 1 = /4). Whether he accomplished this by inventing a system as good as calculus or without the aid of calculus; either way it is astonishing. **Stanley Wolpert** says: " An untutored Kerala mathematician named Madhava developed his own system of calculus, based on his knowledge of trigonometry around A.D. 1500, more than a century before either Newton or Liebnitz.

(source: **An Introduction to India - By Stanley Wolpert** p. 195).

By the fifteenth century C. E. use of the new mathematical concepts from India had spread all over Europe to Britain, France, Germany, and Italy, among others. **A. L. Basham** states also that

"The debt of the Western world to India in this respect [the field of mathematics] cannot be overestimated. Most of the great discoveries and inventions of which Europe is so proud would have been impossible without a developed system of mathematics, and this in turn would have been impossible if Europe had been shackled by the unwieldy system of Roman numerals. The unknown man who devised the new system was, from the world's point of view, after the Buddha, the most important son of India. His achievement, though easily taken for granted, was the work of an analytical mind of the first order, and he deserves much more honor than he has so far received."

Carl Friedrich Gauss (1777-1855), German scientist and mathematician, was considered as the "prince of mathematics. He is frequently called the founder of modern mathematics, who also studied Sanskrit.

Gauss **"was said to have lamented that Archimedes in the third century B.C. E. had failed to foresee the Indian system of numeration; how much more advanced science would have been."**

Unfortunately, Eurocentrism has effectively concealed from the common man the fact that we owe much in the way of mathematics to ancient India.

In ancient India, mathematics served as a bridge between understanding material reality and the spiritual conception. Vedic mathematics differs profoundly from Greek mathematics in that knowledge for its own sake (for its aesthetic satisfaction) did not appeal to the Indian mind. The mathematics of the Vedas lacks the cold, clear, geometric precision of the West; rather, it is cloaked in the poetic language which so distinguishes the East. Vedic mathematicians strongly felt that every discipline must have a purpose, and believed that the ultimate goal of life was to achieve self-realization and love of God and thereby be released from the cycle of birth and death.

After this period, India was repeatedly raided by muslims and other rulers and there was a lull in scientific research. Industrial revolution and Renaissance passed India by. Before Ramanujan, the only noteworthy mathematician was **Sawai Jai Singh II**, who founded the present city of Jaipur in 1727 A.D. This Hindu king was a great patron of mathematicians and astronomers. He is known for building observatories (**Jantar Mantar**) at Delhi, Jaipur, Ujjain, Varanasi and Mathura. Among the instruments he designed himself are *Samrat Yantra, Ram Yantra and Jai Parkash*.

More recently, intuitive Indian mathematical genius **Srinivas Ramanujan** (1887-1920), a friend to all numbers, was invited to Cambridge by **Prof. G. H. Hardy,** who recognized his brilliance at the sight of his first equation solution. **Julian Huxley** called Ramanujan *"the greatest mathematician of the century."* At the age of thirty he developed a formula for partitioning any natural number, which led to the solving of the Waring problem, expressing an integer as the sum of squares, cubes, or higher powers of a few integers. One day Hardy complained about the cab number that brought him to visit Ramanujan, "1729" as a dull number. Ramanujan responded instantly, " No Hardy, 1729 is a wonderful number! That is the only number which is the sum of two different sets of cubes, 1 and 12, and 9 and 10."

(source: **An Introduction to India - By Stanley Wolpert** p. 195).

Mountstuart Elphinstone wrote: "Their geometrical skill is shown among other forms by their demonstrations of various properties of triangles, especially one which expresses the area in the terms of the three sides, and was unknown in Europe till published by Clavius, and by their knowledge of the proportions of the radius to the circumference of a circle, which they express in a mode peculiar to themselves, by applying one measure and one unit to the radius and circumference. This proportion, which is confirmed by the most approved labors of Europeans, was not known out of India until modern times!"

(source: **History of India - By Mountstuart Elphinstone** London: John Murray Date of Publication: 1849 p. 130).

For more refer to **The Infinitesimal Calculus: How and Why it Was Imported into Europe - By C. K. Raju** and
Computers, mathematics education, and the alternative epistemology of the calculus in the Yuktibhâsâ - By C. K. Raju

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Srinivas Ramanujan: A Life of the Genius

Ramanujan is one of India´s great intellectual heroes, **a mathematical genius** who attributed his brilliance to a personal relationship with a **Hindu Goddess - Namagiri.** His work has been used to help unravel knots as varied as polymer chemistry and cancer, yet how he arrived at this **theorems** is still unknown. By age twelve he had mastered trigonometry so completely that he was inventing sophisticated theorems that astonished teachers. **Mathematicians have mined his theorems ever since.** They've figured out how to prove them. They've put them to use. Only recently, a lost bundle of his notebooks turned up in a Cambridge library. That set mathematics off on a whole new voyage of discovery. And where did all this unproven truth come from? Ramanujan was quick to tell us. He simply prayed to **Sarasvathi, the Goddess of Learning,** and she informed him.

His twenty-one major mathematical papers are still being plumbed for their secrets, and **many of his**

ideas are used today in cosmology and computer science. The unsettling thing is, none of us can find any better way to explain the magnitude of his eerie brilliance.

(source: http://www.uh.edu/engines/epi495.htm) John H. Lienhard (source: **The Man Who Knew Infinity: A Life of the Genius Ramanujan - by Robert Kanigel**)..(source: **Ramanujan** and **Computing the Mathematical face of God**). For more on Ramanuja, refer to chapter on **Quotes321_340**).

Vedic Mathematics

"Vedic Mathematics" is the name given to the ancient system of mathematics, or, to be precise, a unique technique of calculations based on simple rules and principles, with which any mathematical problem — be it arithmetic, algebra, geometry or trigonometry — can be solved. The system is based on 16 **Vedic sutras** or aphorisms, which are actually word-formulae describing natural ways of solving a whole range of mathematical problems. Some examples of sutras are "By one more than the one before", "All from 9 & the last from 10", and "Vertically & Crosswise". These 16 one-line formulae originally written in **Sanskrit,** which can be easily memorized, enables one to solve long mathematical problems quickly.

Born in the Vedic Age, but buried under centuries of debris, this remarkable system of calculation was deciphered towards the beginning of the 20th century, when there was a great interest in ancient Sanskrit texts, especially in Europe. However, certain texts called **Ganita Sutras**, which contained mathematical deductions, were ignored, because no one could find any mathematics in them. These texts, it's believed, bore the germs of what we now know as Vedic Mathematics.

Vedic math was rediscovered from the ancient Indian scriptures between 1911 and 1918 by Sri Bharati Krishna Tirthaji (1884-1960), a scholar of Sanskrit, Mathematics, History and Philosophy. He studied these ancient texts for years, and after careful investigation was able to reconstruct a series of mathematical formulae called *sutras*.

Bharati Krishna Tirthaji, who was also the former **Shankaracharya** of Puri, India, delved into the ancient Vedic texts and established the techniques of this system in his pioneering work — **Vedic Mathematics** (1965), which is considered the starting point for all work on Vedic math. It is said that after Bharati Krishna's original 16 volumes of work expounding the Vedic system were lost, in his final years he wrote this single volume, which was published five years after his death.

(source: **Vedic Mathematics - about.com**). For more refer to chapter on **Glimpses VIII** and **Vedic Math websites**).

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Grammar

"Probably in no other single sphere have Western scholars been so indebted to traditional India as in that of grammar. "

Sir William Wilson Hunter has observed:

" The grammar of **Panini** stands supreme among the grammars of the world, alike for its precision of statement, and for its thorough analysis of the roots of the language and of the formative principles of words. By employing an algebraic terminology it attains a sharp succinctness unrivalled in brevity, but at times enigmatical. **It arranges, in logical harmony, the whole phenomena which the Sanskrit language presents, and stands forth as one of the most splendid achievements of human invention and industry.** So elaborate is the structure, that doubts have arisen whether its complex rules of formation and phonetic change, its polysyllabic derivatives, its ten conjugations with their multiform aorists and long array of tenses, could ever have been the spoken language of a people."

(source: **The Indian Empire - By Sir William Wilson Hunter** p. 142).

The science of linguistics owes much to the brilliant ancient Sanskrit grammarian Panini, whose 4th century B.C. Ashtadhyayi ("Eight Chapters") was the first scientific analysis of any alphabet.

Leonard Bloomfield (1887-1949) American linguist and author of **Language**, published in 1933) characterization of **Panini's Astadhyayi** ("**The Eight Books**")

"**as one of the greatest monuments of human intelligence is by no means an exaggeration; no one who has had even a small acquaintance with that most remarkable book could fail to agree.** In some four thousand sutras or aphorisms - some of them no more than a single syllable in length - Panini sums up the grammar not only of his own spoken language, but of that of the Vedic period as well. The work is the more remarkable when we consider that the author did not write it down but rather worked it all out of his head, as it were. Panini's disciples committed the work to memory and in turn passed it on in the same manner to their disciples; and though the Astadhayayi has long since been committed to writing, rote memorization of the work, with several of the more important commentaries, is still the approved method of studying grammar in India today, as indeed is true of most learning of the traditional culture."

While in the classical world scholars were dealing with language in a somewhat metaphysical way, the Indians were telling us what their language actually was, how it worked, and how it was put together. The methods and techniques for describing the structure of Sanskrit which we find in Panini have not been substantially bettered to this day in modern linguistic theory and practice. We today employ many devices in describing languages that were already known to Panini's first two commentators. The concept of "zero" which in mathematics is attributed to India, finds its place also in linguistics.

"It was in India, however, that there rose a body of knowledge which was destined to revolutionize European ideas about language. The Hindu grammar taught Europeans to analyze speech forms; when one compared the constituent parts, the resemblances, which hitherto had been vaguely recognized, could be set forth with certainty and precision."

(source: **Traditional India -** edited by **O. L. Chavarria-Aguilar** refer to chapter on **Grammar - By Leonard Bloomfield Hall -** Place of Publication: Englewood Cliffs, NJ Date of Publication: 1964 p. 109-113).

Ancient Indian work on grammar was not only objective, systematic, and brilliant than that done in Greece or Rome but is illustrative of their scientific methods of analysis. Although the date of **Panini's** grammar, the **Ashtadhyayi,** ("Eight Chapters"), which comprises about four thousand sutras or aphorisitic rules, is uncertain, it is the earliest extant scientific grammar in the world, having written no later than the fourth century B.C. But prior grammatical analysis is clearly evidenced by the fact that Panini himself mentions over sixty predecessors in the field. For example, the sounds represented by the letters of the alphabet had been properly arranged, vowels and diphthongs separated from mutes, semivowels, and sibilants, and the sounds had been grouped into guttturals, palatals, cerebrals, dentals, and labials.

Panini and other grammarians, especially Katyayana and Patanjali, carried the work much further, and by the middle of the second century B.C. Sanskrit had attained a stereotyped form which remained unaltered for centuries. Whilst Greek grammar tended to be logical, philosophical and syntactical, Indian grammar was the result of an empirical investigation of language done with the objectivity of an anatomist dissecting a body.

At a very early date India began to trace the roots, history, relations and combinations of words. By the fourth century B.C. she had created for herself the science of grammar, and produced probably the greatest of all known grammarians, Panini. The studies of **Panini, Patanjali** and **Bhartrihari** laid the foundations of philology; and that fascinating science of verbal genetics owed almost its life in modern times to the rediscovery of Sanskrit.

It is the discovery of Sanskrit by the West and the study of Indian methods of analysis that revolutionized Western studies of language and laid the foundation of comparative philology. Panini's Sanskrit grammar, produced in about 300 B.C. E. is the shortest and the fullest grammar in the world. Until the mid 19th

century, in fact, Panini's great grammar remained the best standard guide to the study of Sanskrit, an inspiration to students of language everywhere. Even Otto Bohtlingk and Rudolf Roth, whose monumental Sanskrit-German Dictionary, called the "St Petersburg Lexicon" because it was published by the Russian Imperial Academy of Sciences from 1852 to 1875, owed a great debt to Panini's remarkable "Eight Chapters."

(source: **An Introduction to India - By Stanley Wolpert** p. 196).

According to **Sir Monier-Williams** (Eng. Sanskrit scholar 1819-1899):

"The Panini grammar reflects the wondrous capacity of the human brain, which till today no other country has been able to produce except India."

(source: **Hindu Superiority - By Har Bilas Sarda** p. 229).

(For more refer to **Electronic Panini** - **http://sanskrit.gde.to/all_pdf/aShTAdhyAyI.pdf**
and Sanskrit Learning Tools - **http://sanskrit.gde.to/learning_tools/learning_tools.html** and **A Software on Sanskrit Grammar based on Panini's Sutras - http://www.taralabalu.org/panini/greetings.htm**).

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Linguistics

'Sanskrt' is not a language but a linguistic process.

A L Basham says that **the very science of phonetics arose in Europe only after the discovery' of Sanskrt and its grammar by the West.** (Paanini, the seminal thinker, constructed the Ashtaadhyaayee - "the Eight Matters to be Studied" in the 5th cent. BC). His 'structures' constitute a scientific presentation of grammar, phonetics, etymology, linguistics, etc. all rolled into one, not excluding the implied "sociology" of listening to, collecting and statistically evaluating forms of usage in the then spoken language. But, except for scholars like Naom Chomsky, no one working in linguistics overtly acknowledges this debt and **Paanini has yet to be admitted to the pantheon of science** of which Archimedes, Euclid, Socrates, Plato, Newton, Einstein, the Quantum Mechanicists, etc. are the present members. **Paanini's work is of immense importance to modern research in the forms of human speec**h and, possibly, in the mapping of the spread of families of languages (not just of the Indo-European). Such mapping is being currently carried out in the Americas, very likely without the help of Paanini's ideas, in tracing the waves of migration of people that were to become "Red Indians" towards the end of the last Ice Age, from Northeastern Asia, across the Bering Strait, spreading southwards and across the land as far as Tierra del Fuego (the "Land of Fire"; "tierra" = dharaa, by the way) at the southern tip of South America.

One among the major contributions of the **Indian Ancients is the arrangement of letters in the scripts (aksharamalas) of major Indian languages** (Urdu excepted). That and the mode of having one unique symbol per syllable (and the mode of formation of compound consonants) whereby, with every letter having a fixed and invariable pronunciation, the script "is adapted to the expression of every gradation of sound" (source: **Practical Grammar of the Sanskrit Language - By Sir Monier-Williams** 1857).

(source: **Whence and Whither of Indian Science - Can we integrate with our past and carry on from there? – Contributed by S. N. Balasubrahmanyam** - (Retd) Professor of Organic Chemistry at the Indian Institute of Science, Bangalore).

(For more on grammar please refer to chapter on **Sanskrit**).

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Science

The revolutionary contents of the Vedas

For a quick glimpse at what unsung surprises may lie in the Vedas, let us consider these renditions from the Yajur-veda and Atharva-veda, for instance.

" O disciple, a student in the science of government, **sail in oceans in steamers, fly in the air in airplanes**, know God the creator through the Vedas, control thy breath through yoga, through astronomy know the functions of day and night, know all the Vedas, Rig, Yajur, Sama and Atharva, by means of their constituent parts."

" Through astronomy, geography, and geology, go thou to all the different countries of the world under the sun. Mayest thou attain through good preaching to statesmanship and artisanship, through medical science obtain knowledge of all medicinal plants, through hydrostatics learn the different uses of water, through electricity understand the working of ever lustrous lightening. Carry out my instructions willingly." (**Yajur-veda** 6.21).

" O royal skilled engineer, construct sea-boats, propelled on water by our experts, and airplanes, moving and flying upward, after the clouds that reside in the mid-region, that fly as the boats move on the sea, that fly high over and below the watery clouds. Be thou, thereby, prosperous in this world created by the Omnipresent God, and flier in both air and lightning." (**Yajur-veda** 10.19).

" The atomic energy fissions the ninety-nine elements, covering its path by the bombardments of neutrons without let or hindrance. Desirous of stalking the head, ie. The chief part of the swift power, hidden in the mass of molecular adjustments of the elements, this atomic energy approaches it in the very act of fissioning it by the above-noted bombardment. Herein, verily the scientists know the similar hidden striking force of the rays of the sun working in the orbit of the moon." (**Atharva-veda** 20.41.1-3).

(source: **Searching for Vedic India - By Devamitra Swami** p. 155 - 157). For more refer to chapter on **Vimanas** and **Advanced Concepts**).

Medieval Arab scholar **Sa'id ibn Ahmad al-Andalusi** (1029-1070) wrote in his **Tabaqat al-'umam**, one of the earliest books on history of sciences:

"The first nation to have cultivated science is India. ... India is known for the wisdom of its people. Over many centuries, all the kings of the past have recognized the ability of the Indians in all the branches of knowledge".

"The kings of China have stated that the kings of the world are five in number and all the people of the world are their subjects. They mentioned the king of China, the king of India, the king of the Turks, the king of the Persians, and the king of the Romans.

"... **They referred to the king of India as the "king of wisdom" because of the Indians' careful treatment of 'ulum [sciences] and all the branches of knowledge.**

"The Indians, known to all nations for many centuries, are the metal [essence] of wisdom, the source of fairness and objectivity. They are people of sublime pensiveness, universal apologues, and useful and rare inventions.

"... To their credit the Indians have made great strides in the study of numbers and of geometry. They have acquired immense information and reached the zenith in their knowledge of the movements of the stars [astronomy] ... After all that they have surpassed all other peoples in their knowledge of medical sciences ..."

In his book **al-Andalusi** goes on to give details of several Indian texts on astronomy and tells us that the Arab scholars used them in preparing their own almanacs.

" Ancient Indian theories lacked an empirical base, but they were brilliant imaginative explanations of the physical structure of the world, and in a large measure, agreed with

the discoveries of modern physics."

(source: In the eleventh-century, an important manuscript titled **The Categories of Nations** was authored in Arabic by **Said al-Andalusi**, who was a prolific author and in the powerful position of a judge for the king in Muslim Spain. A translation and annotation of this was done S.I. Salem and Alok Kumar and published by University of Texas Press: “Science in the Medieval World”. This is the first English translation of this eleventh-century manuscript. Quotes are from Chapter V: “Science in India”).

- A. L. Basham, Australian Indologist

Two system of Indian thought propound physical theories suggestively similar to those of Greece. **Kanada,** founder of the Vaishehika philosophy, held that the world was composed of *atoms* as many in kind as the various elements. The Jains approximated to Democritus by teaching that all atoms were of the same kind, producing different effects by diverse modes of combination. Kanada believed light and heat to be varieties of the same substance; **Udayana** taught that all heat comes from the sun; and **Vachaspati,** like Newton, interpreted light as composed of minute particles emitted by substances and striking the eye. Musical notes and intervals were analyzed and mathematically calculated in the Indian treatises on music. and the Pyrthogorean Law was formulated by which the number of vibrations, and therefore the pitch of the note, varies inversely as the length of the string between the point of attachment and the point of touch.

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The calculation of eclipses was given by Indian astronomers, refer to verses from Varahamihira's texts, which give the true reasons for eclipses as the earth's and moon's shadows (no rAhu kEtu here).

For more refer to **History of Indian Science & Technology**.

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Education

The world's first university was established at Takshashila (northwest region of India) in approximately 700 B.C. The Universities in ancient India were entirely residential. It was considered that a University should contain at least 21 Professors well versed in Philosophy, Theology and Law; pupils were given free tuition, free boarding, and students who went to an educational institution - be the king or a peasant - lived and boarded together. Ashramas, Viharas and Parishads were great centers of culture and attracted large numbers.

When Alexander reached Punjab in 327 BC, Takshashila, the world's oldest university was already established as a place of learning. **John Keay** in his book **India: a History**" writes:

"Students went there to learn the purest Sanskrit. Kautilya, whose Arthashashtra is the classic Indian treatise on statecraft, is said to have been born there in the third century BC. It was also in Taxila that, in the previous century, Panini compiled a grammar more comprehensive and scientific than any dreamed of by Greek grammarians. The glory for the western world is the library of Alexandria, which was sanctioned by Ptolemy I Soter, the successor of Alexander of Macedonia in around 300 BC. While the **Maurya empire** was in power in India..."

Dr. Ernest Binfield Havell (1861-1934) principal to the Madras College of Art in the 1890s and left as principal of the Calcutta College of Art some 20 years later. He wrote several books, including his book, **Indian Architecture - Its Psychology, Structure and History from the First Mohammedan Invasion to the Present Day** has remarked:

"From the Guru the student would pass, about the age of sixteen, to one of the great universities that were the glory of ancient and medieval India. Benares, Taxila, Vidarbha, Ajanta, Ujjain or Nalanda. Benares was the stronghold of learning in Buddha's days. Taxila was known at the time of Alexander's invasion, was known to all of Asia as the leading seat of Hindu scholarship, renowned above all for its medical school; Ujjain was held in high repute for astronomy, Ajanta for the teaching of art. The facade of one of the ruined buildings at Ajanta suggests the magnificence of these old universities."

(source: **Story of Civilization: Our Oriental Heritage** - **By Will Durant** MJF Books.1935 p. 556-557).

When **Cyrus the Great** (558-530 B.C.), came to the throne, the city of Takshasila, was already a center of learning and trade. Young men from Magadha were sent there to finish their education. **The Jataka tales show that young men from all over the civilized part of India sought education in this city, as well as from Persia and Mesopotamia.**

The campus accommodated 10,500 students and offered over sixty different courses in various fields, such as science, mathematics, medicine, politics, warfare, astrology, astronomy, music, religion, and philosophy. The minimum age for admission was 16 years and students from as far as Babylonia, Greece, Syria, Arabia, and China came to study at the university. Taxila, stood on the banks of the river Vitasa in the northwest of the Indian subcontinent.

Panini, the great Sanskrit grammarian, Charaka, the author of famous treatise on medicine, and **Chanakya,** writer of **Artha Shastra** -- these august names are associated with Taxila. **Promising minds from far flung regions converged there to study the Vedas and all branches of secular knowledge.** Takshasila or Taxila, as the Greeks called it over 2,000 years ago, was at one of the entrances to the splendor that was India. Its antiquity is rooted both in epic texts like the Ramayana, Mahabharata and the other Puranas. The Jakatas are full of references to Taxila - over 100 in fact. We gleam a good many details about it from them. Mention is made of world-renowned professors who taught the Vedas, the Kalas, Shilpa, Archery and so on. King Kosala and **Jivaka,** the famous physician were students of the University, the latter learning medicine under Rishi Atreya. Great stress was laid on the study of Sanskrit and Pali literature.

The University of Vikramasila accommodated 8,000 people. It was situated on a hill in Magadha on the banks of the Ganga and flourished for four centuries. It was destroyed along with Nalanda by the Mohammedan invasion. They speak of Kulapatis in those times; the technical meaning of the word is 'one who feeds' and teaches 10,000 students'. **Kanva** was one such Kulapati. Kalidasa speaks of the various kinds of knowledge taught and learnt under the guidance of Kanva.

The University of Nalanda built in the 4th century BCE was one of the greatest achievements of ancient India in the field of education. **Buddha** visited Nalanda several times during his lifetime. The Chinese scholar and traveler **Hiuen Tsang** stayed here in the 7th century, and has left an elaborate description of the excellence, and purity of monastic life practiced here. About 2,000 teachers and 10,000 students from all over the Buddhist world, lived and studied in this international university. In this first residential international university of the world, 2,000 teachers and 10,000 students from all over the Buddhist world lived and studied here.

It had ten thousand students, one hundred lecture-rroms, great libraries, and six immense blocks of dormitories four stories high; its observatories, said **Yuan Chwang**, "were lost in the vapors of the morning, and the upper rooms towered above the clouds." The old Chinese pilgrim loved the learned monks and shady groves of Nalanda so well he stayed there for five years.

(source: **Story of Civilization: Our Oriental Heritage** - **By Will Durant** MJF Books.1935 p. 556-557 and **Facets of Indian Culture** - **By R. Srinivasan** Publisher: Bhartiya Vidya Bhavan p. 237-239).

The Gupta kings patronized these monasteries, built in old Kushan architectural style, in a row of cells around a courtyard. Ashoka and Harshavardhana were some of its most celebrated patrons who built temples and monasteries here. Recent excavations have unearthed elaborate

structures here. Hiuen Tsang had left ecstatic accounts of both the ambiance and architecture of this unique university of ancient times. The Nalanda university counted on its staff such great thinkers as **Nagarjuna, Aryadeva, Vasubhandu, Asanga, Sthiramati, Dharmapala, Silaphadra, Santideva and Padmasambhava. The ancient universities were the sanctuaries of the inner life of the nation.** Another large university was established at Nalanda around 500 B.C. Approximately one mile long and half-mile wide, this campus housed a large library, called Dharam gunj (Treasure of Knowledge), that spread over three buildings, known as Ratna Sagar, Ratnadevi, and Ratnayanjak. Among other facilities, the university included 300 lecture halls, several laboratories, and an astronomical research observatory called **Ambudharavlehi**. The university used handwritten manuscripts for teaching and attracted students and staff from many countries, including China, Korea and Japan. According to the Chinese traveler Hieun Tsang, the campus housed 10,000 students, 2,000 professors, and a large administrative staff.

(source: **The Hindu Mind - Fundamentals of Hindu Religion and Philosophy for All Ages - By Bansi Pandit** B & V Enterprises, Inc ISBN: 0963479849 p. 302).

These universities were sacked, plundered, looted by the Islamic onslaught.

According to historian **Will Durant**:

"The Mohemmedans destroyed nearly all the monasteries, Buddhist or Hindu, in northern India. Nalanda was burned to the ground in 1197 and all its monks were slaughtered; we can never estimate the abundant life of ancient India from what these fanatics spared."

(source: **Story of Civilization: Our Oriental Heritage - By Will Durant** MJF Books.1935 p. 558).

The **Moghuls** neglected practical and secular learning, especially the sciences. **Throughout their long rule, no institutions was established comparable to modern university, although early India had world-famous centers of learning such as Taxila, Nalanda and Kanchi.** Neither the nobles nor the mullas were stirred into learning...

For more on education, refer to chapter on **Education in Ancient India**).

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Chemistry and metallurgy

Sir Mountstuart Elphinstone has written: "Their (Indians) chemical skill is a fact more striking and more unexpected." "They knew how to prepare sulphuric acid, nitric acid and muratic acid; the oxide of copper, iron, lead (of which they had both the red oxide and litharge), tin and zinc: the suphuret of iron, copper, mercury, and antimony, and arsenic; the sulphate of copper, zinc and iron; and carbonates of lead and iron. Their modes of preparing these substances were sometimes peculiar."

(source: **History of Hindu Chemistry - By Mountstuart Elphinstone** Volume I, Introduction, p. xii and 54).

Chemistry developed from two source - medicine and industry. Something has been said about the chemical excellence of cast iron in ancient India, and about the high industrial development of Gupta Period, when India was looked to, even by Imperial Rome, as the most skilled of the nations in such chemical industries as dyeing, tanning, soap-making, glass and cement. As early as the second century B.C. **Nagarjuna** devoted an entire volume to mercury. By the sixth century Indians were far ahead of Europe in industrial chemistry; they were masters of calcination, distillation, sublimation, steaming, fixation, the production of light without heat, the mixing of anesthetic and soporific powders, and the preparation of metallic salts, compounds and alloy.

Abundant evidence available suggests that the ancient Indians were highly skilled in manufacturing and working with iron and in making and tempering steel. The analysis of zinc alloys like brass, from archaeological excavations, testify that the zinc distillation process was known in India as early as 150 B.C. Indian steel, famous worldwide, is mentioned in history books which tell us that when Alexander invaded India, Porus, otherwise known as **Purushottam**, presented him with thirty pounds of steel, thus indicating its high value.

South India was a region that was renowned for metallurgy and metalwork in the old days. In Karnataka, fine steel wires were being produced for use as strings in musical instruments, at a time when the western world was using animal gut for the same purpose. Kerala, besides its large iron smelting furnaces, boasted of special processes such as the metal mirror of Aranmula. High quality steel from Tamil Nadu was exported all over the world since Roman times. **The Konasamudram region in Andhra Pradesh was famous for producing the world renowned Wootz steel - the raw material for King Saladin's fabled Damascus Sword. The tempering of steel was brought in ancient India to a perfection unknown in Europe till our own times. King Porus is said to have selected, as special valuable gift for Alexander, not gold or silver, but thirty pounds of steel.** The Muslims took much of this Indian chemical science and industry to the Near East and Europe; the secret of manufacturing "Damascus" blades, for example, was taken by Arabs from the Persians, and by the Persians from India.

Persians considered Indian swords to be the best, and the phrase, " Jawabi hind, literally meaning " Indian answer," meant "a cut with the sword made of Indian steel." That the art of metarllurgy was highly developed in ancient India is further reaffirmed by the fact that the Gypsies, who originated in India, are highly skilled craftsmen, and it has been suggested that the art of the forge may have been transmitted to Europe through Gypsies. Steel was manufactured in ancient India, and it was being exported to China at least by the fifth century A.D. That the Arabs also imported steel from India is testified to by **Al Kindi**, who wrote in the ninth century.

Coinage dating from the 8th Century B.C. to the17th Century A.D. Numismatic evidence of the advances made by Smelting technology in ancient India. The image of Nataraja the God of Dance is made of five metals (Pancha-Dhatu). This technology of mixing two or more metals and deriving superior alloys has been observed and noted by the Greek Historian **Philostratus.** The Makara (Spire) over Hindu temples were always adorned with brass or gold toppings (Kamandals). The earliest reference to the advances made in Smelting technology in India are by Greek historians viz, Philostratus and Ktesias in the 4th century B.C.

Great progress was made in India in mineralogy and metallurgy. The mining and extensive use of gold, silver, and copper was undertaken in the Indus Valley in the third century B.C. In the vedic period extensive use was made of copper, bronze, and brass for household utensils, weapons, and images for worship. Patanjali, writing in the second century B.C. in his *Lohasastra,* gives elaborate directions for many metallurgic and chemical processes, especially the preparation of metallic salts, alloys, and amalgams, and the extraction, purification, and assaying of metals. The discovery of aqua regia (a mixture of nitric and hydrochloric acid to dissolve gold and platinum) is ascribed to him. Numerous specimens of weapons made of iron have been excavated, probably belonging to the fourth century B.C. Iron clamps and the iron stag found at the Bodhgaya temple point to the knowledge of the process of manufacturing iron as early as the third century B.C.

Horace Hyman Wilson (1786-1860) says: "The Hindus have the art of smelting iron, of welding it, and of making steel, and have had these arts from times immemorial."

(source: **History of British India - By James Mill** volume II p. 47).

Saladin's sword

The finest Damascus steel was made by a process known only to Indians. The original Damascus steel-the world's first high-carbon steel-was a product of India known as wootz. Wootz is the English for ukku in Kannada and Telugu, meaning steel. Indian steel was used for making swords and armour in Persia and Arabia in ancient times. Ktesias at the court of Persia (5th c BC) mentions two swords made of Indian steel which the Persian king presented him. The pre-Islamic Arab word for sword is 'muhannad' meaning from Hind.

Wootz was produced by carburising chips of wrought iron in a closed crucible process. "Wrought iron, wood and carbonaceous matter was placed in a crucible and heated in a current of hot air till the iron became red hot and plastic. It was then allowed to cool very slowly (about 24 hours) until it absorbed a fixed amount of carbon, generally 1.2 to 1.8 per cent," said eminent metallurgist Prof. T.R. Anantharaman, who taught at Banares Hindu University, Varanasi. "When forged into a blade, the carbides in the steel formed a visible pattern on the surface." To the sixth century Arab poet Aus b. Hajr the pattern appeared described 'as if it were the trail of small black ants that had trekked over the steel while it was still soft'.

The carbon-bearing material packed in the crucible was a clever way to lower the melting-point of iron (1535 degrees centigrade). The lower the melting-point the more carbon got absorbed and high-carbon steel was formed. In the early 1800s, Europeans tried their hand at reproducing wootz on an industrial scale. **Michael Faraday, the great experimenter and son of a blacksmith, tried to duplicate the steel by alloying iron with a variety of metals but failed. Some scientists were successful in forging wootz but they still were not able to reproduce its characteristics, like the watery mark.** "Scientists believe that some other micro-addition went into it," said Anantharaman. "That is why the separation of carbide takes place so beautifully and geometrically."

(source: **Lost knowledge** - The Week June 2001).

Hindus made the best swords in the ancient world, they discovered the process of making Ukku steel, called Damascus steel by the rest of the world (**Damas meaning water to the Arabs, because of the watery designs on the blade**). These were the best swords in the ancient world, the strongest and the sharpest, sharper even than Japanese katanas. Romans, Greeks, Arabs, Persians, Turks, and Chinese imported it. **The original Damascus steel-the world's first high-carbon steel-was a product of India known as wootz. Wootz is the English for ukku in Kannada and Telugu, meaning steel.** Indian steel was used for making swords and armor in Persia and Arabia in ancient times. Ktesias at the court of Persia (5th c BC) mentions two swords made of Indian steel which the Persian king presented him. **The pre-Islamic Arab word for sword is 'muhannad' meaning from Hind. So famous were they that the Arabic word for sword was Hindvi - from Hind.**

The crucible process could have originated in south India and the finest steel was from the land of Cheras, said K. Rajan, associate professor of archaeology at Tamil University, Thanjavur, who explored a 1st century AD trade centre at Kodumanal near Coimbatore. Rajan's excavations revealed an industrial economy at Kodumanal. **Pillar of strength The rustless wonder called the Iron Pillar near the Qutb Minar at Mehrauli in Delhi did not attract the attention of scientists till the second quarter of the 19th century. The inscription refers to a ruler named Chandra, who had conquered the Vangas and Vahlikas, and the breeze of whose valour still perfumed the southern ocean. "The king who answers the description is none but Samudragupta, the real founder of the Gupta empire," said Prof. T.R. Anantharaman, who has authored The Rustless Wonder. Zinc metallurgy travelled from India to China and from there to Europe.** As late as 1735, professional chemists in Europe believed that zinc could not be reduced to metal except in the presence of copper. The alchemical texts of the mediaeval period show that the tradition was live in India. In 1738, William Champion established the Bristol process to produce metallic zinc in commercial quantities and

got a patent for it. Interestingly, the mediaeval alchemical text Rasaratnasamucchaya describes the same process, down to adding 1.5 per cent common salt to the ore.

(source: **Saladin's sword** - **The Week** - June 24, 2001 - **http://netinfo.hypermart.net/telingsteel.htm**).

Iron Pillar - The Rustless Wonder and a Unique Scientific Phenomenon from Ancient India. A product of great metallurgical ingenuity

Traditional Indian iron and steel are known to have some very special properties such as resistance to corrosion. This is substantiated by the 1600-year-old, twenty-five feet high iron pillar next to the Qutub Minar in New Delhi, believed to have been installed during Chandragupta Maurya's reign. The famous **iron pillar** in Delhi belonging to the fourth-fifth century A.D. is a metallurgical wonder. This huge wrought iron pillar, 24 feet in height 16.4 inches in diameter at the bottom, and 6 1/2 tons in weight has stood exposed to tropical sun and rain for fifteen hundred years, but does not show the least sign of rusting or corrosion. Evidence shows that the pillar was once a **Garuda Stambha from a Vishnu temple.** This pillar was plundered by Islamic hoards from a temple dedicated to Vishnu and added as a trophy in the Quwwat al-Islam mosque in Delhi. Made of pure iron, which even today can be produced only in small quantities by electrolysis. Such a pillar would be most difficult to make even today. Thus, the pillar defies explanation.

The pillar is believed to have been made by forging together a series of disc-shaped iron blooms. Apart from the dimensions another remarkable aspect of the iron pillar is the absence of corrosion which has been linked to the composition, the high purity of the wrought iron and the phosphorus content and the distribution of slag.

Even with today's advances, only four foundries in the world could make this piece and none are able to keep it rust free. The earliest known metal expert (2,200 years ago) was **Rishi Patanjali.**

The pillar is a solid shaft of iron sixteen inches in diameter and 23 feet high. What is most astounding about it is that it has never rusted even though it has been exposed to wind and rain for centuries! The pillar defies explanation, not only for not having rusted, but because it is apparently made of pure iron, which can only be produced today in tiny quantities by electrolysis! The technique used to cast such a gigantic, solid pillar is also a mystery, as it would be difficult to construct another of this size even today. The pillar stands as mute testimony to the highly advanced scientific knowledge that was known in antiquity, and not duplicated until recent times. Yet still, there is no satisfactory explanation as to why the pillar has never rusted!

(source: **Technology of the Gods: The Incredible Sciences of the Ancients** - **By David Hatcher Childress** p. 80).

The Delhi Iron Pillar is a testimony to the high level of skill achieved by the ancient Indian ironsmiths in the extraction and processing of iron.

Refer to **Delhi Iron Pillar** - **By Prof. R. Balasubramaniam - Professor Department of Materials and Metallurgical Engg Indian Institute of Technology, Kanpur 208016.**

Contributed to this site by Prof. R. Balasubramaniam. URL: http://home.iitk.ac.in/~bala

The pillar is a classical example of massive production of high class iron and is the biggest hand-forged block of iron from antiquity. It is a demonstration of the high degree of accomplishment in the art of iron making by ancient Indian iron and steel makers. It has been said that the Indians were the only non-European people who manufactured heavy forged pieces of iron and the pieces were of the size that the European smiths did not learn to make more than one thousand years later.

The iron pillar near New Delhi is an outstanding example of Gupta craftmanship. Its total height inclusive of the capital is 23 feet 8 inches. Its entire weight is 6 tons. The pillar consists of a square abacus, the melon shaped member and a capital. According to **Percy Brown**, **this pillar is a remarkable tribute to the genius and manipulative dexterity of the Indian worker. Dr. Vincent Smith** says: "It is not many years since the production of such a pillar would have been an impossibility in the largest foundries of the world and even now there are comparatively few where a similar mass of metal could be turned out."

(source: **Ancient India - By V. D. Mahajan** p. 543).

The iron pillar has an inscription in Samskritam written in Brahmi script. **It is a Vishnu Dhvaja on a hill called Vishnupaada. Installed by King Chandra.**

"*He, on whose arm fame was inscribed by the sword, when, in battle in the Vanga countries, he kneaded (and turned) back with (his) breast the enemies who, uniting together, came against (him);-he, by whom, having crossed in warfare the seven mouths of the (river) Sindhu, the Vâhlikas were conquered;-he, by the breezes of whose prowess the southern ocean is even still perfumed;-*

(Line 3.)-He, the remnant of the great zeal of whose energy, which utterly destroyed (his) enemies, like (the remnant of the great glowing heat) of a burned-out fire in a great forest, even now leaves not the earth; though he, the king, as if wearied, has quitted this earth, and has gone to the other world, moving in (bodily) form to the land (of paradise) won by (the merit of has) actions, (but) remaining on (this) earth by (the memory of his) fame;-

(L. 5.)-By him, the king,-who attained sole supreme sovereignty in the world, acquired by his own arm and (enjoyed) for a very long time; (and) who, having the name of Chandra, carried a beauty of countenance like (the beauty of) the full-moon,-having in faith fixed his mind upon (the god) Vishnu, this lofty standard of the divine Vishnu was set up on the hill (called) Vishnupada."

(source: **yahoogroups - Indian Civilization**).

The excellent state of preservation of the Iron Pillar, near the Qutb Minar at Mehrauli in Delhi, despite exposure for 15 centuries to the elements has amazed corrosion technologists.

In 1961, the pillar (23 feet and 8 inches, and 6 tonnes) was dug out for chemical treatment and preservation and reinstalled by embedding the underground part in a masonry pedestal. Chemical analyses have indicated that the pillar was astonishingly pure or low in carbon compared with modern commercial iron.

Traditional Indian iron and steel are known to have some very special properties such as resistance to corrosion. This is substantiated by the 1600-year-old, twenty-five feet high iron pillar next to the Qutub Minar in New Delhi, believed to have been installed during Chandragupta Maurya's reign. Reports of an international seminar conducted by the National Metallurgical Laboratory at Jamshedupur in 1963 on the Delhi Iron Pillar, showed that the pillar's corrosion resistance was not merely the result of some fortuitous circumstances or Delhi's low humidity, but **the product of great metallurgical ingenuity.** In fact, rust-proof iron has been found in very humid areas as well. A temple, dedicated to the Goddess Mookambika, is located in Kolur in Kodachadri Hills in Karnataka - a region which receives a heavy annual monsoon. A slender iron pillar near the Mookambika temple stands unrusted despite the severe climatic conditions that it is subjected to.

(source: **Center for Indian Knowledge Systems** - http://www.ciks.org/methist.html)

The iron pillar near Qutub Minar at New Delhi is in the news, thanks to the research by Prof. R. Balasubramaniam of IIT, Kanpur and his team of metallurgists. **The pillar is said to be 1,600 years old.** A protective layer of `misawite' — a compound made up of iron, oxygen and hydrogen on the steel pillar, which is said to contain phosphorus - is claimed as the reason for the non-corrosive existence.

(source: **Iron pillar and nano powder -** http://www.hinduonnet.com/thehindu/seta/stories/2002082900020200.htm

All this historical evidence points to the fact that there existed a body of knowledge in the fields of metallurgy and metalworking which, if rediscovered and re-implemented, could revolutionize the country's iron and steel industry.

The **Periplus** mentions that in the first century A.D. Indian iron and steel were being exported to Africa and Ethiopia. Indian metallurgists were well known for their ability to extract metal from ore and their cast products were highly valued by the Romans, Egyptians, and Arabs.

Even in technology Indian contribution to world civilization were significant. **The spinning wheel is an Indian invention, and apart from its economic significance in reducing the cost of textiles, is one of the first examples of the belt-transmission of power.** The stirrup, certainly the big-toe stirrup, is of second century B.C. Indian origin. The ancient blow-gun (**nalika**), which shot small arrows or iron pellets, may well have been a forerunner of the air-gun which is supposed to have been invented by the Europeans in the sixteenth century.

More important is the fact that India supplied the concept of perpetual motion to European thinking about mechanical power. The origin of this concept has been traced to Bhaskara, and it was taken to Europe by the Arabs where it not only helped European engineers to generalize their concept of mechanical power, but also provoked a process of thinking by analogy that profoundly influenced Western scientific views. **The Indian idea of perpetual motion is in accordance with the Hindu belief in the cyclical and self-renewing nature of all things.**

In fact, rust-proof iron has been found in very humid areas as well. A temple, dedicated to the Goddess Mookambika, is located in Kolur in Kodachadri Hills in Karnataka - a region which receives a heavy annual monsoon. A slender iron pillar near the Mookambika temple stands unrusted despite the severe climatic conditions that it is subjected to.

Galvanising feat

The oldest among the triad of metallurgical marvels of ancient India is the extraction of zinc. Zinc is better known as a constituent of brass than a metal in its own right. Brass with 10 per cent zinc glitters like gold.

The earliest brass objects in India have been unearthed from Taxila (circa 44 BC). They had more than 35 per cent zinc. "This high content of zinc could be put in only by direct fusion of metallic zinc and copper," said Prof. T.R. Anantharaman. The other process, which is no more in use, is by heating zinc ore and copper metal at high temperatures, but the zinc content in brass then cannot be more than 28 per cent.

Zinc smelting is very complicated as it is a very volatile material. Under normal pressure it boils at 913 degrees centigrade. To extract zinc from its oxide, the oxide must be heated to about 1200 degrees in clay retorts. In an ordinary furnace the zinc gets vapourised, so there has to be a reducing atmosphere. By an ingenious method of reverse distillation ancient metallurgists saw to it that there was enough carbon to reduce the heat.

Proof of the process came from excavations at Zawar in Rajasthan. The Zawar process consisted of heating zinc in an atmosphere of carbon monoxide in clay retorts arranged upside down, and collecting zinc vapour in a cooler chamber placed vertically beneath the retort.

Zinc metallurgy traveled from India to China and from there to Europe. As late as 1735, professional chemists in Europe believed that zinc could not be reduced to metal except in the presence of copper. The alchemical texts of the mediaeval period show that the tradition was live in India.

(source: **Lost knowledge** - The Week June 2001).

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Manufacture of Iron and Steel in India

The substance which seems to have evoked the most scientific and technical interest in the Britain of the 1790s was the sample of **wootz steel** by Dr. Scott to Sir J. Banks, the President of the British Royal Society. The sample went through thorough examination and analysis by several experts. It was found in general to match the best steel then available in Britain, and according to one user, "purpose of fine cutlery, and particularly for all edge instruments used for surgical purposes."

After its being sent as a sample in 1794 and its examination and analysis in late 1794 and early 1795, it began to be much in demand, and some 18 years later the afore-quoted user of steel stated, "I have to use it for many purposes. If a better steel is offered to me, I will gladly attend to it; **but the steel of India is decidedly the best** I have yet met with."

Till well into the 19th Britain produced very little of the steel it required and imported it from Sweden, Russia, etc. Partly, Britain lag in steel production was due to the inferior quality of its iron ore, and the fuel, i.e. coal, it used. Possibly such lag also resulted from Britain's backwardness in the comprehensive of processes and theories on which the production of good steel depended.

Whatever may have been the understanding in the other European countries regarding the details of the processes employed in the manufacture of Indian steel, the British, at the time wootz was examined and analysed by them, concluded, "that it is made directly from the ore and consequently it has never been in the state of wrought iron." Its qualities were thus ascribed to the quality of the ore from which it came and these qualities were considered to have little to do with the techniques and processes employed by the Indian manufacturers. In fact it was felt that the various cakes of wootz were of uneven texture and the cause of such imperfection and defects was thought to lie in the crudeness of the techniques employed.

It was only some three decades later that this view was revised. An earlier revision in fact, even when confronted with contrary evidence as was made available by other observers of the Indian techniques and processes, was intellectual impossibility. "That iron could be converted into cast steel by fusing it in a close vessel in contact with carbon" was yet to be discovered, and it was only in 1825 that a British manufacturer "took out a patent for converting iron into steel by exposing it to the action of caruretted hydrogen gas in a close vessel, at a very high temperature, by which means the process of conversion is completed in a few hours, while by the old method, it was the work of from 14 to 20 days."

According to **J. M. Heath**, founder of the Indian Iron and Steel Company, and later prominently connected with the development of steel making in Sheffield, the Indian process appeared to combine both of the above early 19th century British discoveries. He observed: "**Now it appears to me that the Indian process combines the principles of both the above described methods.** On elevating the temperature of the crucible containing pure iron, and dry wood, and green leaves, an abundant evolution of carburetted hydrogen gas would take place from the vegetable matter, and as its escape would be prevented by the luting at the mouth of the crucible, it would be retained in contact with the iron, which, at a high temperature, appears from (the above mentioned patent process) to have a much greater affinity for gaseous than for conrete carbon; this would greatly shorten the operation, and probably at a much lower temperature than were the iron in contact with charcoal powder."

And he added: **"In no other way can I account for the fact that iron is converted into cast steel by the natives of India, in two hours and half, with an application of heat,** that, in this country, would be considered quite inadequate to produce such an effect; while at Sheffield it requires at least four hours to melt blistered steel in wind-furnaces of the best construction, although the crucibles in which the steel is melted, are at a white heat when the metal is put into them, and in the Indian process, the crucibles are put into the furnace quite cold."

(source: **Indian Science and Technology in the 18th Century - By Dharampal**).

Dr. Ray says: “Coming to comparatively later times, we find that the Indians were noted for their skill in tempering of steel. The blades of Damascus were held in high esteem, but it was from India that the Persians, and, through them, the Arabs learnt the secret of the operation. The wrought iron pillar close to the Kutub

Minar, near Delhi, which weighs ten tons and is some 1,500 years old, the huge iron girders at Puri, the ornamental gates of Somnath, and the 24 feet wrought iron gun at Nurvar, are monuments of a bygone art, and bear silent but eloquent testimony to the marvelous metallurgical skill attained by the Hindus."

Regarding the iron pillar, **James Fergusson** (1808-1886) says: "It has not, however, been yet correctly ascertained what its age really is. There is an inscription upon it, but without a date. From the form of its alphabet, James Prinsep ascribed it to the third or fourth century." Fergusson continues, "Taking A.D 400 as a mean date – and it certainly is not far from the truth – it opens our eyes to an unsuspected state of affairs, to find the Hindus at that age capable of forging a bar of iron larger than any that have been forged even in Europe up to a very late date, and not frequently even now. As we find them, however, a few centuries afterwards using bars as long as this lat in roofing the porch of the temple at Kanaruc, we must now believe that they were much more familiar with the use of this metal than they afterwards became. It is almost equally startling to find that after an exposure to wind and rain for fourteen centuries it is unrusted, and the capital and inscription are as clear and as sharp now as when put up fourteen centuries ago. There is no mistake about the pillar being of pure iron. General Alexander Cunningham had a bit of it analyzed in the School of Mines here by Dr. Percy. Both found it to be pure malleable iron without any alloy."

Mrs. Charlotte Manning says: "The superior quality of Hindu steel has long been known, and it is worthy of record that the celebrated Damascus blades, have been traced to the workshops of Western India." She adds: "Steel manufactured in Kutch enjoys at the present day a reputation not inferior to that of the steel made in Glasgow and Sheffield." "It is probable that ancient India possessed iron more than sufficient for her wants, and that the Phoenicians fetched iron with other merchandise from India."

(source: **Hindu Superiority - By Har Bilas Sarda** p. 400-404).

Iron suspension bridges came from Kashmir in India. **Papermaking was commonplace in India and China. European explorers depended heavily on Indian ship builders.**

(source: **Lost Discoveries: The Ancient Roots of Modern Science - By Dick Teresi** p. 326).

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Predicting earthquakes - was dealt with in detail in the 32nd chapter of **Varahamihira's Brihat Samhita.**

The greatness of philosopher, mathematician and astronomer Varahamihira (505-587 AD) is widely acknowledged. The Ujjain-born scholar was one of the Navaratnas in the court of King Vikramaditya Chandragupta II. His works, *Pancha-Siddhantika* (The Five Astronomical Canons) and *Brihat Samhita* (The Great Compilation), are considered seminal texts on ancient Indian astronomy and astrology.

What has astonished scientists and Vedic scholars and has renewed interest in the Brihat Samhita, are references to unusual "earthquake clouds" as precursor to earthquakes.

The 32nd chapter of the manuscript is devoted to signs of earthquakes and correlates earthquakes with cosmic and planetary influences, underground water and undersea activities, unusual cloud formations, and the abnormal behaviour of animals.

Varahamihira categorises earthquakes into different kinds and says that the indications of one particular kind will appear in the form of unusual cloud formations a week before its occurrence: "Its indications appearing a week before are the following: Huge clouds resembling blue lily, bees and collyrium in colour, rumbling pleasantly, and shining with flashes of lightning, will pour down slender lines of water resembling sharp clouds. An earthquake of this circle will kill those that are dependent on the seas and rivers; and it will lead to excessive rains." 1500 years ago a celebrated astronomer-astrologer-mathematician sought to study earthquakes on the Indian subcontinent. He drew correlations between terrestrial earth, the atmosphere and planetary influences. He described earth as a mass floating on water and spoke of unusual cloud formations and abnormal animal behaviour as precursors to earthquakes."

"All in all, this should be accepted as nothing but astounding."

(source: **A temblor from ancient Indian treasure trove? - Times of India** 4/28/01).

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Diamomds were first mined in India

Knowledge of diamond and the origin of its many connations starts in India, where it was first mined. The word most generally used for diamond in Sanskrit is translitereated as **vajra**, "thunderbolt," and indrayudha, "Indra's weapon." Because **Indra is the warrior god from Vedic scriptures**, the foundation of Hinduism, the thunderbolt symbol indicates much about the Indian conception of diamond. The flash of lightning is a suitable comparison for the light thrown off by a fine diamond octahedron and a diamond's indomitable hardness. Early descriptions of vajra date to the 4th century BCE which is supported by archaeological evidence. By that date diamond was a valued material.

Writings: The earliest known reference to diamond is a Sanskrit manuscript, the **Arthasastra** ("The Lesson of Profit") by **Kautiliya,** a minister to Chandragupta of the Mauryan dynasty in northern India. The work is dated from 320-296 before the Common Era (BCE). Kautiliya states "(a diamond that is) big, heavy, capable of bearing blows, with symmetrical points, capable of scratching (from the inside) a (glass) vessel (filled with water), revolving like a spindle and brilliantly shining is excellent. That (diamond) with points lost, without edges and defective on one side is bad." Indians recognized the qualities of a fine diamond octahedron and valued it.

(source: **American Museum of Natural History**).

The **Ratnapradeepika** deals with diamonds, precious stones and pearls. The word **Vajrah** suggests diamonds in general, and the properties in general. The Maharshis such as Shounaka have divided diamonds into 4 classes - Khanija, Kulaja, Shilaja and Kritaka. It also deals with the manufacturing of artificial diamonds. The salts of alum, borax and ooshara are regarded as the best ones for this purpose.

(source: **Diamonds, Mechanisms, Weapons of War and Yoga Sutras - By G. R. Joyser** International Academy of Sanskrit Research. p. 1-14).

Pliny, the Roman writer (AD 23-79) calls **India "the sole mother of precious stones," and the "great producer of the most costly gems."**

(source: **Sanskrit Civilization - By G. R. Josyer** International Academy of Sanskrit Researches p. 192).

Arthur George Parkin, the well known expert in natural coloring, writes in his work that the process of coloring thread perfectly with blue and bright red (Manjista) was known to India from times immemorial and they earned immense money out of the export trade of colored thread.

(source: **Ancient Indian Culture At A Glance - By Swami Tattwananda** Calcutta, Oxford Book Co. 1962 p. 131).

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Military science - Gunpowder

In regard to military science, the Ramayana and the Puranas make frequent mention of **Shataghnis**, or canons, being placed on forts and used in times of emergency. A canon was called **"Shataghni"** because it meant the fire weapon that kills one hundred men at once. They ascribe these **agniyastras, or weapons of fire**, to Visvakarma, the architect of the Vedic epics. Rockets were also Indian inventions and were used in native armies when Europeans first came into contact with them. As per **Dante's Inferno**, Alexander mentioned in a

letter to Aristotle, that terrific flashes of flame showered on his army in India. The **Shukra Neeti** is an ancient text that deals with the manufacture of arms such as rifles and guns. In **The Celtic Druids** (pp-115-116), **Godfrey Higgins** provides evidence that Hindus knew of gun powder from the remotest antiquity.

(source: **Proof of Vedic Culture's Global Existence - By Stephen Knapp** p. 27-28).

According to **Sir A. M. Eliot** and **Heinrich Brunnhofer** (a German Indologist) and **Gustav Oppert**, all of whom have stated that ancient Hindus knew the use of gunpowder. Eliot tells us that the Arabs learnt the manufacture of gunpowder from India, and that before their Indian connection they had used arrows of naptha. It is also argued that though Persia possessed saltpetre in abundance, the original home of gunpowder was India. In the light of the above remarks we can trace the evolution of fire-arms in the ancient India.

(source: **German Indologists: Biographies of Scholars in Indian Studies writing in German - By Valentine Stache-Rosen**. p.92). (For more information on Military science please refer to chapter on **War in Ancient India**).

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Vimanas

"The ancient Hindus could navigate the air, and not only navigate it, but fight battles in it like so many war-eagles combating for the domination of the clouds. To be so perfect in aeronautics, they must have known all the arts and sciences related to the science, including the strata and currents of the atmosphere, the relative temperature, humidity, density and specific gravity of the various gases..."

~ **Col. Henry S Olcott** (1832 – 1907) American author, attorney, philosopher, and cofounder of the **Theosophical Society** in a lecture in Allahabad, in 1881.

For more information refer to chapter on **Vimanas**.

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The Process of Making Ice in the East Indies - By Sir Robert Barker published in 1775

Following is the method that was used to make ice in India as it was performed at Allahabad and Calcutta. On a large open plain, 3 or 4 excavations were made, each about 30 feet square and two deep; the bottoms of which were strewed about eight inches or a foot thick with sugar-cane, or the stems of the large Indian corn dried. Upon this bed were placed in rows, near to each other, a number of small shallow, earthen pans for containing the water intended to be frozen. These are unglazed, scarce a quarter of an inch thick, about an inch and a quarter in depth, and made of an earth so porous, that it was visible, from the exterior part of the pans, the water had penetrated the whole substance. Towards the dusk of the evening, they were filled with soft water, which had been boiled, and then left in the afore-related situation. The ice-makers attended the pits usually before the sun was above the horizon, and collected in baskets what was frozen, by pouring the whole contents of the pans into them, and thereby retaining the ice, which was daily conveyed to the grand receptacle or place of preservation, prepared generally on some high dry situation, by sinking a pit of fourteen or fifteen feet deep, lined first with straw, and then with a coarse king of blanketing, where it is beat down with rammers, till at length its own accumulated cold again freezes and forms one solid mass. The mouth of the pit is well secured from the exterior air with straw and blankets, in the manner of the lining, and a thatched roof is thrown over the whole.

Ice making in India. It was made in open pans.

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The spongy nature of the sugar-canes, or stems of the Indian corn, appears well calculated to give a passage under the pans to the cold air; which, acting on the exterior parts of the vessels, may carry off by evaporating a proportion of the heat. The porous substance of the vessels seems equally well qualified for the admission of the cold air internally; and their situation being full of a foot beneath the plane of the ground, prevents the surface of the water from being ruffled by any small current of air, and thereby preserves the congealed particles from disunion. Boiling the water is esteemed a necessary preparative to this method of congelation.

In effecting which there is also an established mode of proceeding; the sherbets, creams, or whatever other fluids are intended to be frozen, are confined in thin silver cups of a conical form, containing about a pint, with their covers well luted on with paste, and placed in a large vessel filled with ice, salt-petre, and common salt, of the two the last an equal quantity, and a little water to dissolve the ice and combine the whole. This composition presently freezes the contents of the cups to the same consistency of our ice creams, etc. in Europe; but plain water will become so hard as to require a mallet and knife to break it. The promising advantages of such a discovery could alone induce the Asiatic to make an attempt of profiting by so a very short a duration of cold during the night in these months, and by a well-timed and critical contrivance of securing this momentary degree of cold, they have procured to themselves a comfortable refreshment as a recompence, to alleviate, in some degree, the intense heats of the summer season, which, in some parts of India, would be scarce supportable, but by the assistance of this and many other inventions.

(source: **Indian Science and Technology in the 18th Century - By Dharampal** p. 169-173).

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Shipbuilding and Navigation

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The art of Navigation was born in the river Sindh 6000 years ago. The very word Navigation is derived from the Sanskrit word NAV Gatih. The word navy is also derived from Sanskrit `Nou'.The Vedic Age was a period of tremendous wealth and prosperity. The primary sources of knowledge about the Vedic Age is the Rig Veda. It was a cooperating society based on generate wealth. *Gold* (Hiranya in Sanskrit) was very valuable in this

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period. The Rig Veda even refers to gifts of gold necklaces reaching down to the chest (Hiranya plural). Gold was smelted from the beds of the rivers Saraswati and Sindhu (Indus). **The Rig Veda not only refer to the Saraswati as Hiranyavartani, or the path of gold** (and the Sindhu as Hiranmayi or made of gold), it also makes a direct reference to panned-gold from the Saraswati river bed. **Trade was also a big part of this civilization. There is overwhelming evidence that this civilization traded with the Egyptians (with the Sumerians acting as intermediaries). This directly implies the use of ships. In fact, the Rig Veda makes several references to ships used to cross the "Samudra."**

India was a peninsula cut off from the Northern world by the Himalayas, and from the Eastern and Western, by vast expanses of water, India had to take to shipping, if she wanted to export her immense surplus goods. Literature as well as art expresses the life of a people, and evidences from Indian literature and art prove that in ancient times, India had developed her own shipping. **Professor Georg Buehler** (1837-1898), the German Orientalist, said:

"There are passages in ancient Indian works which prove the early existence of a navigation of the Indian Ocean, and the somewhat later occurrence of trading voyages undertaken by Hindu merchants to the shores of the Persian Gulf and its rivers. No commerce can thrive unless fostered by national shipping. The world's leading anthropologists, **Robert Heine Geldern and Gordon F. Ekholm** have strongly supported the claim that Indian ships went all the way to Mexico and Peru centuries before Columbus. In the "**Civilizations of Ancient America**" they state:

"There appears to be little doubt but that ship building and navigation were sufficiently advanced in southern and eastern Asia at the period in question to have made trans-Pacific voyages possible. In the third century, horses were exported from India to the Malay Peninsula and Indo-China, an indication that there must have been ships of considerable size."

(source: **India: Mother of us All - Edited by Chaman Lal** p. 43-44).

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History of Indian Navy
http://armedforces.nic.in/navy/nahist.htm

India's maritime history predates the birth of western civilization. The world's first tidal dock is believed to have been built at Lothal around 2300 BC during the Harappan civilization, near the present day Mangrol harbour on the Gujarat coast.

Ancient Indian ocean-going ship arriving at Java, from a frieze of the Borobodur stupa.

The Rig Veda, written around 2000 BC, credits Varuna with knowledge of the ocean routes commonly used by ships and describes naval expeditions using hundred-oared ships to subdue other kingdoms. There is a reference to **Plava,** the side wings of a vessel which give stability under storm conditions: perhaps the precursor of modern stabilisers. Similarly, the Atharva Veda mentions boats which were spacious, well constructed and comfortable.

In Indian mythology, Varuna was the exalted deity to whom lesser mortals turned for forgiveness of their sins. It is only later that Indra became known as the King of the Gods, and Varuna was relegated to become the God of Seas and Rivers. The ocean, recognized as the repository of numerous treasures, was churned by the Devas and Danavas, the sons of Kashyapa by queens Aditi and Diti, in order to obtain Amrit, the nectar of immortality. Even today the invocation at the launching ceremony of a warship is addressed to Aditi.

The influence of the sea on Indian kingdoms continued to grow with the passage of time. North-west India came under the influence of Alexander, who built a harbor at Patala where the Indus branches into two just before entering the Arabian Sea. His army returned to Mesopotamia in ships built in Sind. Records show that in the period after his conquest, **Chandragupta Maurya established an Admiralty Division under a Superintendent of Ships as part of his war office, with a charter including responsibility for navigation on the seas, oceans, lakes and rivers.** History records that Indian ships traded with countries as far as Java and Sumatra, and available evidence indicates that they were also trading with other countries in the Pacific and Indian Oceans. Even before Alexander there were references to India in Greek works, and India had a flourishing trade with Rome. **The Roman writer Pliny speaks of Indian traders carrying away large quantities of gold from Rome, in payment for much-sought exports such as precious stones, skins, clothes, spices, sandalwood, perfumes, herbs and indigo.**

Trade of this volume could not have been conducted over the centuries without appropriate navigational skills. Two Indian astronomers of repute, **Aryabhatta** and **Varahamihira,** having accurately mapped the positions of celestial bodies, developed a method of computing a ship's position from the stars. **A crude forerunner of the modern magnetic compass was being used around the fourth or fifth century AD. Called Matsya Yantra, it comprised an iron fish that floated in a vessel of oil and pointed North.**

Between the fifth and tenth centuries AD, the Vijaynagaram and Kalinga kingdoms of southern and eastern India had established their rule over Malaya, Sumatra and Western Java. The Andaman and Nicobar Islands then served as an important midway point for trade between the Indian peninsula and these kingdoms, as also with China. The daily revenue from the eastern regions in the period 844-848 AD was estimated at 200 maunds (eight tons) of gold. In the period 984-1042 AD, the Chola kings dispatched great naval expeditions which occupied parts of Burma, Malaya and Sumatra, while suppressing the piratical activities of the Sumatran warlords. *In 1292 AD,* **Marco Polo described Indian ships as " ...built of fir timber, having a sheath of boards laid over the planking in every part, caulked with oakum and fastened with iron nails. The bottoms were smeared with a preparation of quicklime and hemp, pounded together and mixed with oil from a certain tree which is a better material than pitch."**

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The Rig Veda mentions the two oceans to the east and the west, (Bay of Bengal and Arabian Sea) just as they mention ships and maritime trade. Bhujyu, who is one of the main ancestral figures of the Vedic people, is said in the Rig-Veda (1.116.5) to have been brought home safely in a ship with a hundred oars. The idea of a houseboat is implied in several hymns, and so is ocean travel over a period of many days. The Vedic people were well aware that the Indus and Saraswati poured their water into the ocean, that the oceans roars, is ever in motion through its waves, and encircles the land masses.

The picture of the Vedic people as seafaring merchants meshes perfectly with the archaeological evidence of the Indus-Saraswati civilization. Apart from foreign artifacts in the Indus cities and Indus artifacts overseas, there are also steatite seals depicting seaworthy vessels. The seafaring nature of the Hindus is well known from later sources. King Hiram of Tyre (Phoenicia) in 975 B.C. traded with India through the port of Ophir (Supara) near modern Bombay. Harappan seals discovered at several Mesopotamia sites have been dated to about 2400 B.C.

A panel found at Mohenjodaro, depicting a sailing craft. Vessels were of many types. Their construction is vividly

described in the **Yukti Kalpa Taru** an ancient Indian text on Ship-building. There is evidence that a compass made by iron fish floating in a vessel of oil and pointing north was used by mariners. The typical Harappan seals have been found far a field in Oman, Mesopotamia, and the Maldives. These finds bear witness to the enthusiastic initiative of the early Indic peoples as sea faring merchants.

Despite Ancient Concerns about possibly losing caste from crossing the sea, **history reveals India was the foremost maritime nation 2,000 years ago** (meanwhile Europeans were still figuring out the Mediterranean Sea). It had colonies in Cambodia, Java, Sumatra, Japan, China, Arabia, Egypt and more. Through Persians and Arabs, India traded with the Roman Empire. The Sanskrit text, **Yukti Kalpa Taru,** explains how to build ships, such as the one depicted in the Ajanta caves. **It gives minute details about ship types, sizes and materials, including suitability of different types of wood. The treatise also elaborately explains how to decorate and furnish ships so they're comfortable for passengers.**

Yuktikalpataru gives a detailed classification of ships: They were two kinds: ordinary (Samanya) ships comprising those used in inland waters and special (visesa) meant for sea journeys. The largest of these called Manthara measured 120 cubits in length, 60 in breadth and 60 cubits in height. During the days of the composition of Yuktikalpataru, it appears that ship-building was highly advanced. **Bhoja has advised the builders of the sea-faring ships not to join the plants with iron, as, in the case, the magnetic iron in sea water could expose the ship to danger.** To avoid this risk, he suggests that planks of the bottoms should be held together with the help of substances other than iron.

According to **Marco Polo** an Indian ship could carry crews between 100 to 300. Out of regard for passenger convenience and comfort, the ships were well furnished and decorated. Gold, silver, copper and compound of all these substances were generally used for ornamentation and decoration.

(source: **India Through The Ages: History, Art Culture and Religion - By G. Kuppuram** p. 527-531). For more information, refer to chapters on **Seafaring in Ancient India** and **War in Ancient India**).

Recently, an Indian scholar, **B. C. Chhabra**, in his **"Vestiges of Indian Culture in Hawaii",** has noticed certain resemblances between the symbols found in the petroglyohs from the Hawaiian Islands and those on the Harappan seals. Some of the symbols in the petroglyphs are described as akin to early Brahmi script.

Will Durant, eminent American historian, in his book **The Story of civilizations - Our Oriental Heritage** described **India as the most ancient civilization on earth** and he offered many examples of Indian culture throughout the world. He demonstrated that as early as the ninth century B.C. E. Indians were exploring the sea routes, reaching out and extending their cultural influences to Mesopotamia, Arabia, and Egypt.

The art of shipbuilding and navigation in India and China at the time was sufficiently advanced for oceanic crossings. Indian ships operating between Indian and South-east Asian ports were large and well equipped to sail cross the Bay of Bengal. When the Chinese Buddhist scholar, **Fa-hsien,** returned from India, his ship carried a crew of more than two hundred persons and did not sail along the coasts but directly across the ocean. Such ships were larger than those Columbus used to negotiate the Atlantic a thousand years later.

Trade linkages existed between Philippines and with the powerful Hindu empires in Java and Sumatra. These linkages were venues for exchanges with Indian culture, including the adoption of **syllabic scripts** which are still used by indigenous groups in **Palawan** and Mindoro.

According to the work of mediaeval times, **Yukti Kalpataru,**

which gives a fund of information about shipbuilding, India built large vessels from 200 B.C. to the close of the sixteenth century. A Chinese chronicler mentions ships of Southern Asia that could carry as many as one thousand persons, and were manned mainly by Malayan crews. They used western winds and currents in the North Pacific to reach California, sailed south along the coast, and then returned to Asia with the help of the trade winds, taking a more southerly route, without however, touching the Polynesian islands. The New Zealand pre historian, **S. Percy Smith**, tries to show in his **Hawaiki - the Original home of the Maori** that the ancient Polynesian wanderers left India as far back as the fourth century B.C. and were daring mariners who made, more often than not, adventurous voyages with the definite object of new settlements. A people who reached as far east as Easter Island could not have missed the great continent ahead of them.

It was probably gold, which initially attracted Indian adventurers and merchants to Southeast Asia. Southeast Asia was a region broadly referred to by ancient Indians as **Suvarnabhumi (Land of Gold) or Suvarnadvipa (the Island of Gold).** Arab writer **Al Biruni** testify that Indians called the whole Southeast region Suwarndib. Hellenistic geographers knew the area as the Golden Chersonese. The Chinese called it Kin-Lin; kin means gold. The mariners were probably looking for gold or were prospecting for precious metals, stones and pearls to cope with the demand in the centers of ancient civilizations.

"Ships of size that carried Fahien from India to China (through stormy China water) were certainly capable of proceeding all the way to Mexico and Peru by crossing the Pacific. One thousand years before the birth of Columbus Indian ships were far superior to any made in Europe upto the 18th century."

(source: **The Civilizations of Ancient America: The Selected Papers of the XXIXth International Congress of Americanists** - **edited Sol Tax** 1951).

(Please refer to the chapters **Suvarnabhumi: Greater India**, **War in Ancient India** and **Seafaring in Ancient India** for more information about Indian culture in Southeast Asia.)

He has also further noted that Bombay-built ships are at least one-fourth cheaper than those built in the docks of England. **F. Balazar Solvyns**, a Frenchman, wrote a book titled **"Les Hindous"** in 1811.

His remarks are, **"In ancient times, the Indians excelled in the art of constructing vessels, and the present Hindus can in this respect still offer models to Europe-so much so that the English, attentive to everything which relates to naval architecture, have borrowed from the Hindus many improvement which they have adopted with success to their own shipping.... The Indian vessels unite elegance and utility and are models of patience and fine workmanship."**

(source: **http://www.orientalthane.com/speeches/speech_2.htm**).

In ancient times the Indians excelled in shipbuilding and even the English, who were attentive to everything which related to naval architecture, found early Indian models worth copying. **The Indian vessels united elegance and utility, and were models of fine workmanship.**

Sir John Malcolm wrote :

"Indian vessels "are so admirably adapted to the purpose for which they are required that, not withstanding their superior science, Europeans were unable, during an intercourse with India for two centuries, to suggest or at least to bring into successful practice one improvement. "

(source: **Journal of Royal Asiatic Society, Vol. I**).

Kavalam Madhava Panikkar in his book **Asia and Western Dominance** ASIN: B00005VGEZ published by George Allen, London. 1959 says:

"It should be remembered that the Indian Ocean, including the entire coast of Africa, had been explored centuries ago by Indian navigators. Indian ships frequented the East African ports and certainly knew of Madagascar. Vasco da Gama's journey across the Indian Ocean was guided by an Indian pilot whom the King of Milindi had placed at his disposal. Fra Mauro preserves the tradition of two voyages from India past the south end of Africa. He marks the southern cape with the name of Diab and says that an Indian ship in about 1420 was storm-driven to this point and sailed westward to 2,000 miles in forty days, without touching land. Fra Mauro had also spoken himself with a person worthy of confidence who said he had sailed from India, past Sofala to a place called Garbin on the west coast of Africa. The Indian Ocean was therefore a charted sea whose routes were known, and as a navigation achievement long before de Gama.

The Indian Ocean had from time immemorial been the scene of intense commercial trade. Indian ships had from the beginning of history sailed across the Arabian Sea up to the Red Sea ports and maintained intimate cultural and commercial connections with Egypt, Israel and other countries of the Near East. Long before **Hippalus** disclosed the secret of the monsoon to the Romans, Indian navigators had made use of these winds and sailed to the Bab-el-Mandeb. To the east, Indian mariners had gone as far as Borneo and flourishing Indian colonies had existed for over 1,200 years in Malaya, the islands of Indonesia, in Cambodia and Champa and other areas of the coast. Indian ships from Quilon, made regular journeys to the South China coast. A long tradition of maritime life was part of the history of the Peninsular India. The supremacy of India in the waters that washed her coast was unchallenged till the rise of Arab shipping under the early khalifs. **But the Arabs and Hindus competed openly, and the idea of 'sovereignty over the sea' except in the narrow straits was unknown to Asian conception.** Naval fights on any large scale, in the manner of the wars between Carthage and Rome, seem to have been unknown in India before the arrival of the Portuguese."

(source: **Asia and Western Dominance** ASIN: B00005VGEZ published by George Allen, London. 1959 p. 28-30). For more on Shipbuilding in Ancient India, please refer to chapter **Seafaring In Ancient India**).

Sir Aurel Stein (1862-1943) a Hungarian and author of several books including **Ra`jatarangini: a chronicle of the kings of Kashmir** and **Innermost Asia : detailed report of explorations in Central Asia, Kan-su, and Eastern Iran** carried out and described under the orders of H.M. Indian Government, whose valuable researches have added greatly to our knowledge of Greater India, remarks:

"The vast extent of Indian cultural influences, from Central Asia in the North to tropical Indonesia in the South, and from the Borderlands of Persia to China and Japan, has shown that ancient India was a radiating center of a civilization, which by its religious thought, its art and literature, was destined to leave its deep mark on the races wholly diverse and scattered over the greater part of Asia."

(source: **The Vision of India - By Sisir Kumar Mitra** p. 178 and **Main Currents of Indian Culture - By S. Natarajan** p. 50).

"...an Indian naval pilot, named **Kanha**, was hired by Vasco da Gama to take him to India. Contrary to European portrayals that Indians knew only coastal navigation, deep-sea shipping had existed in India. Indian ships had been sailing to islands such as the Andamans, Lakshdweep and Maldives, around 2,000 years ago. Kautiliya's shastras describe the times that are good and bad for seafaring. In the medieval period, Arab sailors purchased their boats in India. **The Portuguese also continued to get their boats from India, and not from Europe. Shipbuilding and exporting was a major Indian industry, until the British banned it.** There is

extensive archival material on the Indian Ocean trade in Greek, Roman, and Southeast Asian sources."

(source: **History of Indian Science & Technology**).

For more on Shipbuilding in Ancient India, please refer to chapter **Seafaring In Ancient India**).

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Commerce

Though the Indians have practically no hand now in the commerce of the world, yet there was a time when they were the masters of the seaborne trade of Europe, Asia and Africa. They built ships, navigated the sea, and held in their hands all the threads of international commerce, whether carried on overland or by sea.

As their immense wealth was in part the result of their extensive trade with other countries, so were the matchless fertility of the Indian soil and the numberless products of Hindu arts and industries the cause of the enormous development of the commerce of ancient India.

As poet William Cowper (1731-1800) wrote: “And if a boundless plenty be the robe,
Trade is a golden girdle of the globe.”

India, which, according to the writer in the Chamber’s Encyclopedia, “has been celebrated during many ages for its valuable natural productions, its beautiful manufactures and costly merchandise,” was, says the Encyclopedia Britannica, “once the seat of commerce.”

Mrs. Charlotte S Manning says: “The indirect evidence afforded by the presence of Indian products in other countries coincides with the direct testimony of Sanskrit literature to establish the fact that the ancient Hindus were a commercial people.” She concludes: “Enough has now been said to show that the Hindus have ever been a commercial people.”

(source: **Ancient and Medieval India – By Charlotte S Manning** volume II p. 354)

Arnold Hermann Ludwig Heeran (1760-1842) says: “The Hindus in their most ancient works of poetry are represented as a commercial people.”

In Sanskrit books, we constantly read of merchants, traders, and men engrossed in commercial pursuits. **Manu Smriti**, one of the oldest books in the world, lays down laws to govern all commercial disputes having reference to seaborne traffic as well as the inland and overland commerce. Traders and merchants are frequently introduced in the Hindu drama. In **Shakuntala** we learn of the importance attached to commerce, where it is stated “that a merchant named Dhanvriddhi, who had extensive commerce had been lost at sea and had left a fortune of many millions.” In **Nala and Damyanti**, too, we meet with similar incidents. **Sir William Jones** is of the opinion that the Hindus “must have been navigators in the age of Manu, because bottomry (marine insurance) is mentioned in it.” In the **Ramayana**, the practice of bottomry is distinctly noticed. **Lord Mountstuart Elphinstone** says: “The Hindus navigated the ocean as early as the age of Manu’s code because we read in it of men well acquainted with sea voyages.

According to **Max Dunker**, ship-building was known in ancient India about 2000 B.C. It is thus clear that the Hindus navigated the ocean from the earliest times and that they carried on trade on an extensive scale with all the important nations of the Old World.

(source: **History of Antiquity – By Max Dunker** volume IV).

With Phoenicia the Indians enjoyed trade from the earliest times. In the tenth century B.C., Soloman of Israel and Hiram of Tyre sent ships to India, whence they carried away ivory, sandalwood, apes, peacocks, gold, silver, precious stones, etc., which they purchased from the tribe of Ophir. Now Ptolemy says there was a country called Abhira at the mouth of the River Indus. This shows that some people called Abhir must have been living there in those days. We find a tribe called the “Abhir” still living in Kathyawar, which must, therefore, be the Ophir tribe mentioned above. **Christian Lassen** (1800-1876) author of **Indische Alterthumskunde** vol I

p. 354, thinks “Ophir” was a seaport on the south west coast of India. **Mrs. Manning** says it was situated on the western coast of India.

Among the things sent by the Hindus to Solomon and Hiram were peacocks. Now, these birds were nowhere to be found in those days except in India, where they have existed from the earliest times. “We frequently meet in old Sanskrit poetry with sentences like these: ‘Peacocks unfolding in glittering glory all their green and gold; ‘peacocks dancing in wild glee at the approach of rain;’ peacocks around palaces glittering on the garden walls.’ Ancient sculptures, too show the same delight in peacocks, as may be seen, for instance, in graceful bas-reliefs on the gates of Sanchi or in the panels of an ancient palace in Central India, figured in Colonel Tod’s Rajastathan p. 405. “The word for peacock in Hebrew is universally admitted to be foreign; and Gesenius, **Sir Emerson Tennent**, and **Max Muller** appear to agree with Christian Lassen in holding that this word as written in Kings and Chronicles is derived from the Sanskrit language.

With regard to ivory, it was largely used in India, Assyria, Egypt, Greece and Rome. Elephants are indigenous in India and Africa, and ivory trade must be either of Indian origin or African. But the elephants were scarcely known to the ancient Egyptians, and C Lassen decides that elephants were neither used nor tamed in ancient Egypt. In ancient India, they were largely used and tamed. All the kings processions and battles have elephants mentioned in them. The elephant is the emblem of royalty and a sign of rank and power. The god Indra, too has his ‘Airawat.’ The Sanskrit name for domestic elephant is ibha, and in the bazaars of India ibha was the name by which the elephant’s tusks were sold. In ancient Egypt, ivory was known by the name of ebu.

It would be interesting to many to learn that “it was in India that the Greeks first became acquainted with sugar.” Sugar bears a name derived from Sanskrit. With the article the name traveled into Arabia and Persia, and thence became established in the languages of Europe.

Samuel Maunder (1785-1849) in his **The Treasury of History** wrote: “In the reign of Seleucidas, too, there was an active trade between India and Syria.” Indian iron and colored cloths and rich apparels were imported in Babylon and Tyre in ships from India. There were also commercial routes to Phoenicia, through, Persia. **Lord Mountstuart Elphinstone** says: “The extent of the Indian trade under the first Ptolemies is a well known fact in history.” **Vincent Smith** observes that in the Book of Genesis, “a caravan of camels loaded with the spices of India and balm and myrrh of Hadramaut.” **John Forbes Royle** in his book **Ancient Hindu Medicine** p. 119, observes that myrrh is called bal by the Egyptians, while its Sanskrit name is bola, bearing a resemblance which leaves no doubt as to its Indian manufacture.

Of the products of the loom, silk was more largely imported from India into ancient Rome than either in Egypt or Greece. “It was so alluring the Roman ladies,” says a writer, “that it sold for its weight in gold.” This is confirmed by the elder Pliny, who complained that vast sums of money were annually absorbed by commerce with India. “We are assured on undisputed authority that the Romans remitted annually to India, a sum equivalent to 4,000,000 pounds to pay for their investments, and that in the reign of Ptolemies 125 sails of Indian shipping were at one time lying in the ports whence Egypt, Syria, and Rome itself were supplied with the products of India.”

(source: **Annals and Antiquities of Rajasthan: or the Central and Western Rajput States of India** - **By Colonel James Tod** p. 221).

Agarthachides, who lived upwards of 300 years before the time of Periplus, noticed the active commercial intercourse kept up between Yemen and Pattala – a seaport town, in Sindh. Pattala in Sanskrit means a “commercial town.” “which circumstance, if it is true, says **Arnold Hermann Ludwig Heeran** “would prove the extreme antiquity of the navigation carried on by the Indus.”

Max Dunker wrote: “Trade existed between the Indians and Sabaens on the coast of south Arabia before the 10^{th} century B.C. – the time according to some when Manu lived. In the days of Alexander, when the Macedonian general, Nearchus, was entering the Persian Gulf, Muscat was pointed out to him as the principal mart for Indian products which were transmitted thence to Assyria.

Egypt was not the only part of Africa with which the Hindus traded in olden days. The eastern coast of Africa called Zanibar and the provinces situated on the Red Sea carried on an extensive trade with ancient India. Myos Hormos, was the chief emporium of Indian commerce on the Red Sea. Of the trade with Zanzibar,

Periplus gives us pretty full information. He says: “Moreover, indigenous products such as corn, rice, butter, oil of seasamum, coarse and fine cotton goods, and cane-honey (sugar) are regularly exported from the interior of Ariaka (Konkan), and from Barygaza (Baroucha/Broach) to the opposite coast.”

This trade is also noticed by Arrian, who adds that “this navigation was regularly managed.”

Arnold Hermann Ludwig Heeran (1760-1842) says, it is a well known fact that the banians or Hindu merchants were in the habit of traversing the oceans and settling in foreign countries. The Eastern countries with which ancient India traded were chiefly China, Trangangetic Peninsula and Australia. Professor Heeran says that “the second direction, which the trade of India took was towards the East, that is, to the Ultra-Gangetic Peninsula, comprising Ava Mallaca, etc. The Hindus themselves were in the habit of constructing the vessels in which they navigated the coast of Coromandel (Cholamandel), and also made voyages to the Ganges and the peninsula beyond it. These ships bore different names according to their sizes.

Land Trade

As regards the trade with central and northern Asia, we are told that “the Indians make expeditions for commercial purposes into the golden desert Ideste, desert of Cobi, in armed companies of a thousand or two thousand men. But, according to a report, they do not return home for three or four years.” The Takhti Suleman, or the stone tower mentioned by **Ptolemy** and **Ctesias**, was the starting point for Hindu merchants who went to China.

Arnold Hermann Ludwig Heeran says: “By means of this building it is easy to determine the particular route as well as the length of time employed by the Hindu merchants in their journey to China. If we assume Cabul, or rather Bactria, as their place of departure, the expedition would take a north-easterly direction as far as the forty-first degree of the north latitude. It would then have to ascend the mountains, and so arrive at the stone tower through the defile of Hoshan, or Owsh. From thence the route led by Cashgar, beyond the mountains to the borders of the great desert of Cobi, which it traversed probably through Khotan and Aksu (the Casia and Auxazia of Ptolemy). From these ancient towns the road lay through Koshotei to Se-chow, on the frontiers of China, and thence to Pekin, a place of great antiquity. The whole distance amounts to upwards of 2,500 miles.”

Foreign trade of a nation presupposes development of its internal trade. Specially is this true of a large country like India, with its varied products, vast population and high civilization.

Christian Lassen (1800-1876) of Paris considers it remarkable that the Hindus themselves discovered the rich, luxurious character of India’s products; many of them are produced in other countries, but remained unnoticed until sought for by foreigners, where as the most ancient Hindus had a keen enjoyment in articles of taste and luxury. Rajas and other rich people delighted in sagacious elephants, swift horses, splendid peacocks, golden decorations, exquisite perfumes, pungent peppers, ivory, pearls, gems, gold etc. and consequently caravans were in continued requisition to carry down these and innumerable other matters between the north and the south, and the west and the east of their vast and varied country. These caravans, were met at border stations and about ports by western caravans or ships bound to or from Tyre and Egypt or to or from the Persian Gulf and Red Sea.”

Strabo, Plutarch, and **Apollodoras** agree in their statements that India had considerable trade roads in all directions, with mile stones, and was provided with inns for travelers. And these “roads” says Heeran, “were planted with trees and flowers.”

Active internal commerce was carried on in northern India along the course of the Ganges. Here was the royal highway extending from Taxila on the Indus to Patliputra (in Bihar) and which was 10,000 stadia in length, according to Strabo.

Periplus, too, after saying that “the Ganges and its tributary streams were the grand commercial routes of northern India,” adds that the “rivers of the Southern Peninsula also were navigated.”

According to **Arrian,** the commercial intercourse between the eastern and western coasts were carried on in

country built ships. Periplus again says that "in Dachhanabades (Dakshina Patha in Sanskrit, or the Deccan) there are two very distinguished and celebrated marts, named Tagara and Pluthama, whence merchandise was bought down to Barygaza (Barauch). Ozene (Ujjain) was one of the chief marts for internal traffic, and supplied the neighboring country with all kinds of merchandise.

The Encyclopedia Britannica says: "It (India) exported its most valuable produce, its diamonds, its aromatics, its silks, and its costly manufactures. The country, which abounded in those expensive luxuries, was naturally reputed to be the seat of immense riches, and every romantic tale of its felicity and glory was readily believed. In the Middle Ages, an extensive commerce with India was still maintained through the ports of Egypt and the Red Sea; and its precious produce, imported into Europe by the merchants of Venice, confirmed the popular opinion of its high refinement and its vast wealth."

(source: **Hindu Superiority – By Har Bilas Sarda** p 405-426).

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Wealth

If history proves anything, **it proves that in ancient times, India was the richest country in the world.** The fact that she has always been the cynosure of all eyes, Asiatic or European, that people of less favored climes have always cast longing looks on her glittering treasures, and that the ambition of all conquerors has been to possess India, prove that she has been reputed to be the richest country in the world. Her sunny climate, unrivalled fertility, matchless mineral resources and world-wide exports in ancient times helped to accumulate in her bosom the wealth which made her the happy hunting grounds of adventurers and conquerors.

Strabo (c. 63 BC-3 BC) Greek historian in his book **Geography II**, 5, 12. Describing the location of India and calls it **"the greatest if all nations and the happiest in lot."**

(source: **India and World Civilization By D. P. Singhal** Pan Macmillan Limited. 1993. p. 385).

Arnold Hermann Ludwig Heeran (1760-1842) says: **"India has been celebrated even in the earliest times for her riches."** The wealth, splendor and prosperity of India had made a strong impression on the mind of Alexander the Great, and that when he left Persia for India, he told his army that they were starting for that "Golden India" where there was endless wealth, and that what they had seen in Persia was as nothing compared to the riches of India. **Chamber's Encyclopedia** says" "India has been celebrated during many ages for its wealth." The writer of the article "Hindustan" in the **Encyclopedia Britannica** remarks that India "was naturally reputed to be the seat of immense riches." **Milton** voiced the popular belief when he sang of the wealth of India:

"High on a throne of royal state which far
Outshone the wealth of Ormuz and of Ind (India)
Or where the gorgeous East with richest hand
Showers on her kings barbaric, pearl and gold."

To Shake the Pagoda Tree

William Finch who came to India in 1608-11, first described Hindu temples as "pagods, which are stone images of monstrous men feareful to behold. He mentioned the temples in Ajmer, "three faire Pagodes richly wrought with inlayd works, **adorned richly with jewels. Domingo Paes** has left a valuable account of the great Hindu kingdom of Vijayanagar. He saw outside the city very beautiful pagodas, the chief among them was the temple of Vitthalasvamin which was begun by Krsnadeva Raya. Edward Terry, the chaplain to Sir Thomas Roe, King James's emissary described the temple of Nagarkot as **'most richly set forth, both scaled and paved with plate of pure gold." The wealth of the temples stirred Jean Thevenot imagination and he wrote about the temples of Benares and Puri that 'nothing can be more magnificent than these Pagodes...by reason of the quantity of gold and many jewels, wherewith they are adorned."**

Most foreigners came to India in search of her fabulous wealth. **No traveler found India poor until the nineteenth century, but foreign merchants and adventurers sought her shores for the almost fabulous wealth, which they could there obtain.**

'To shake the pagoda tree' became a phrase, somewhat similar to our modern expression 'to strike oil' or to get rich quick.

(source: **Much Maligned Monsters: A History of European Reactions to Indian Art - By Partha Mitter** p. 1 - 45).

An idea of the immense wealth of India could be gathered from the fact that when Sultan Mahmud Ghaznavi destroyed the **far famed temple of Somnath** he found such immense riches and astonishing diamonds cooped up in the single **“Idol of Shiva” that it was found quite impossible to calculate the value of that booty.**

Gold, the emblem of wealth, was first found in India. India was the home of diamonds and other precious stones in ancient times. **Periplus** says that “the Greeks used to purchase pieces of gold from the Indians.” Nelkynda or Neliceram, a port near Calicut on the Malabar Coast, is said to have been the only market for pearls in the world in ancient times. The pearls presented by Julius Ceasar to Servilia, the mother of Brutus, as well as the famous pearl earring of Cleopatra, were obtained from India. The most famous diamonds in the world are natives of India. Though the **Pitt** (or the Regent as it is now called) weights 136 carats and is larger in size, yet the **Kohinoor,** weighing only 106 carats, hallowed by ages of romantic history, is the most famous diamond in the world. Both were taken from India by the British. But the mythological and historical value of the Kohinoor is untold.

The Priceless Peacock Throne

What is the costliest single treasure made in the last 1,000 years? Wrought out of 1150 kg of gold and 230 kg of precious stones, conservatively in 1999 the throne would be valued at $804 million or nearly Rs 4.5 billion. In fact when made, it cost twice as much as the Tajmahal. On the top of each pillar there were to be two peacocks, thick-set with gems and between each two peacocks a tree set with rubies and diamonds, emeralds and pearls. The ascent was to consist of three steps set with jewels of fine water". Of the 11 jewelled recesses formed around it for cushions, the middle one was intended for the seat it for Emperor. Among the historical diamonds decorating it were the famous **Kohinoor** (186 carats). It was one of the most splendiferous thrones ever made. it was encrusted with 26,733 precious stones! Ascended by silver steps, it was sheeted with gold encrusted with emeralds and rubies. Its back was a peacock's tail of sapphires, pearls and turquoises. The throne was completed after seven years of unceasing labour by the best craftsmen of the empire and was valued at 10 million rupees or Rs 500 crore today.

(source: **As priceless as the Peacock Throne - By K. R. N. Swamy - tribuneindia.com).** For more on the Kohinoor diamond refer to chapter on **Glimpses VIII.**

It was the wealth of India that impelled the rude Arabs to invade the country, and led the half civilized Tartans to overrun it. It was the wealth of India that attracted **Nadir Shah**, the **Portuguese** and then the **British.**

(source: **Hindu Superiority – By Har Bilas Sarda** p 427 - 430). For more refer to chapters on **Islamic Onslaught** and **European Imperialism**

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